Global Liquidity Provision and Risk Sharing

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Abstract

This study examines the role of international markets for liquidity provision and risk sharing using a full sample of U.S. firms traded on 20 foreign exchanges since 1901 with stock return and liquidity data from 1950. The tests show that in market downturns the liquidity of cross-listed firms is significantly higher than that of companies that are listed only domestically. This result is especially strong when firms are cross-listed on multiple exchanges, as well as in larger and more liquid markets. The liquidity enhancement from the firm's presence in foreign stock markets is particularly effective for firms with high return volatility, high foreign income, and high probability of informed trading. The subsequent estimation reveals that foreign trading in firm shares lead to significant reduction in two liquidity betas, which are based on the sensitivity of firm liquidity to its domestic market liquidity and its domestic market return. Our findings therefore highlight the importance of global financial markets for supplying liquidity and reducing liquidity risk.

JEL classifications: G11; G14; G15
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1. Introduction

The recent financial crisis of 2007-2009 witnessed an evaporation of liquidity in many segments of financial markets. Recent studies argue that the market illiquidity could result from funding illiquidity during market downturns (Khandani and Lo, 2007; Franzoni and Moussawi, 2012; Brunnermeier and Pedersen, 2009; Aragon and Strahan, 2012; Ben-David, Franzoni, and Moussawi, 2012).[1] For instance, speculators may risk hitting their margin constraints and be forced to liquidate their assets as a consequence of a sharp market decline. In addition, tighter risk management by financial intermediaries in response to higher volatility during market turmoil reduces their borrowing capability and restricts dealers from providing market liquidity (Hameed, Kang, and Viswanathan, 2010; Nagel, 2012). The funding liquidity, market liquidity and how they interact with each other are of important concern to many investors. Although the causal impact of funding liquidity on market liquidity in U.S. markets has received much attention, the interaction between international securities markets under the condition of *unsynchronized* funding constraints is a relatively unexplored area.[2]

In an international context, the impact direction of funding liquidity on market liquidity is not straightforward (Gromb and Vayanos, 2002). Consider a domestic market and a foreign market facing distinct funding constraints. On the one hand, after a significant negative shock in the foreign market, the foreign intermediaries may reach their margin limits in their own market and be obliged to liquidate their holdings also in the domestic market. In this case, international investors act as *net liquidity demanders* by intensifying the selling pressure in the domestic market during foreign market downturns. On the other hand, during the domestic market turmoil, capital constraints become binding in the home market and, consequently, drive asset prices

[1] An asset's market liquidity is defined as "the ease with which it is traded" and trader's funding liquidity means "the ease with which traders can obtain funding".

[2] Garleanu and Pedersen (2011) derive a consumption CAPM augmented by a security's margin times the general funding cost. Their model suggests a considerable funding risk premium for a stock if its margin requirements deteriorate during market declines. A theoretical model by Brunnermeier and Pedersen (2009) links the market liquidity and funding liquidity indicating that they can mutually reinforce each other and lead to liquidity spirals. Overall, the theoretical results in these studies call for a better understanding of the issue on how market liquidity and funding liquidity risk interact with each other under in international setting.

away from their fundamental values. Foreign arbitrageurs, unaffected by these tightening funding constraints, may provide liquidity by taking the advantage of arbitrage opportunities in the domestic market. In this case, international investors behave as *net liquidity suppliers* by providing liquidity to the domestic market during its downturns. While several studies find substantial evidence of commonality in liquidity around the world, the aggregate liquidity at a given exchange is only partially driven by a global commonality component (see Brockman, Chung, and Perignon, 2009; Karolyi, Lee, and Van Dijk, 2012).[3] Therefore, the equilibrium effect of international markets on liquidity is unclear.

This paper addresses the aforementioned issue and examines the effect of funding liquidity in international markets on the market liquidity in the United States. Specifically, we study three distinct but interrelated issues. Can international market participants supply liquidity to the U.S. equity market during its declines? What is the impact on market liquidity in the United States from negative shocks in foreign markets? What are the implications from global market exposure on the measurements of liquidity risk?

We accomplish our goals using a full sample of U.S. firms cross-listed in 20 foreign markets since 1901 with the return and liquidity data covering more than a 60-year time period from 1950 until 2013. This setting gives several advantages. First, focusing on the United States as a domestic market allows us to work with a substantially longer time period than if we were dealing with other markets. Our gain is not so much from the availability of stock return based data, but from the possibility of using longer and more precise time-series of liquidity measures in our analysis, in particular, the Amihud liquidity (see Goyenko, Holden, and Trzcinka, 2009). The rich U.S. data also allows us to look deeper into the impact of firm-level characteristics on the propensity of international markets to provide any shielding from the liquidity drain. Second, using cross-listings allows us to understand how pools of different investors with dissimilar margin constraints that exist across international markets (e.g., Beber and Pagano, 2013) affect

[3] Kamara, Lou, and Sadka (2008) show that commonality in liquidity has even decreased over time for the cross-section of stocks in the United States.

the liquidity of two otherwise almost identical (in the time-series or cross-section) U.S. firms with the single main difference being that one is traded globally, while the other is not. This helps better isolate liquidity effects from other possible influences. In addition, since the beginning of the 20^{th} century, U.S. firms have placed their shares in various developed markets of Canada, Europe, Japan, and Australasia, without a clear dominance of any of the foreign market in our overall sample.[4] As a result, we are able to test our main relations in a variety of foreign market environments. [5]

First, we find that global markets can significantly improve the liquidity of U.S. firms during U.S. market downturns. In particular, while the liquidity of U.S. firms that are listed only at home dries up significantly in bear markets consistent with the previous literature (see Hameed, Kang, and Viswanathan, 2010), the negative U.S. market return leads to much smaller reduction in liquidity among U.S. firms following the first placement of their stocks abroad. This pattern remains intact after the inclusion of various firm-level controls and shows similar results in the two 32-year sub-periods of our sample. Moreover, in the worst U.S. market conditions (the bottom return quartile), the positive liquidity effect of cross-listings completely offsets the reduction in liquidity resulting from the domestic market downturn. We also find that the average impact of negative U.S. market shocks on firm liquidity innovations is much smaller (by about 50%) for cross-listed firms than for the comparable sample of matched firms without foreign-traded shares.

The impact from the U.S. firm presence in foreign stock markets on its liquidity varies substantially with different market and firm characteristics. In particular, at the market level, we find that the cross-listing benefits for firm liquidity are especially strong when firms are listed on multiple stock exchanges and when they list in larger and more liquid markets. At the firm level,

[4] Note that certain foreign markets become more attractive for cross-listings during specific time periods, as shown in Sarkissian and Schill (2014).

[5] As shown by Fernandes and Ferreira (2008), cross-listings improve price informativeness, and, therefore, potentially stock liquidity only for firms from developed markets.

we find that the additional liquidity provision induced by cross-listings is also greater for firms with high return volatility, high foreign income, and high probability of informed trading (PIN).

When applying the liquidity provision framework of Nagel (2012), we find that, due to their higher liquidity, the returns of cross-listed firms suffer less from negative market shocks.[6] The reduction in the average magnitude of weekly return reversals for cross-listed firms is 2.5 larger than for similar firms without foreign listings. This reduction is stronger for firms listed in multiple foreign markets, markets with high liquidity and market capitalization, as well as for firms with high PIN, volatility, and foreign income. These tests confirm the transitory effects of stock returns and imply that liquidity innovations are driven by liquidity changes.

Second, negative tendencies in international markets induce very little changes to the liquidity of U.S. firms, irrespective whether they are traded only on domestic exchanges or also overseas. We observe that the liquidity of cross-listed U.S. firms is reduced only marginally from negative shocks in international markets during the periods of strong U.S. equity market performance. This implies that adverse foreign country shocks practically have no damaging effects on the U.S. market liquidity.

Finally, based on the Liquidity CAPM of Acharya and Pedersen (2005), we estimate the impact of cross-listings on the liquidity betas of U.S. firms. We find that the liquidity betas based on the sensitivity of firm liquidity to its domestic market liquidity and its domestic market return are significantly lower for cross-listed firms than for comparable firms listed only on U.S. exchanges. The average difference in these two betas between the two groups of firms is 0.41 and 0.20, respectively.

Thus, our findings illustrate an indispensable role of international markets in supplying liquidity to U.S. firms and, therefore, to the U.S. market as a whole. Liquidity has been understood for some time as an important determinant of asset returns.[7] Most of the existing

[6] Nagel (2012) shows that the returns of short-term reversal strategies can serve as a proxy for the returns from liquidity provision.
[7] Pastor and Stambaugh (2003), Liu (2006), Bekaert, Harvey, and Lundblad (2007), Korajczyk and Sadka (2008), and others find that liquidity is priced factor.

studies have focused on the impact of U.S. stock and bond markets on the stock market liquidity in foreign counties (see Levine and Schmukler, 2006; Lee, 2011; Goyenko and Sarkissian, 2013). Yet, little is known about the other side of the relation. With foreign-owned U.S. long-term securities reaching over $13.2 trillion in 2012, the effect of funding liquidity in international markets on the market liquidity in the United States cannot be ignored.[8] There are also few studies that examine how cross-listings affect firm liquidity (e.g., see Domowitz, Glen, and Madhavan, 1998; Bailey, Karolyi, and Salva, 2006; Chung, 2006; Baruch, Karolyi, and Lemmon, 2007). The common feature of all these papers that differentiates them from our work is that they analyze only changes in the liquidity of foreign firms listed in the United States without any risk-return implications. We use cross-listing universe as a natural setting through which the role of global markets in the provision of liquidity and risk sharing can be better detected and understood in relative isolation to influences of numerous other possible cross-country linkages and frictions.

The rest of the paper is organized as follows. Section 2 describes the cross-listing and stock return data as well as the firm liquidity measures. Section 3 performs tests on the relation between firm's foreign stock market presence and its liquidity. In Section 4 we estimate the effect of liquidity provision on short-term stock return reversals. Section 5 analyses the impact of cross-listings on liquidity betas of U.S. firms. Section 6 concludes.

2. Data

2.1. Cross-Listing Sample

Our study period is from 1950 to 2013. However, the cross-listing sample is from 1901 until 2012 inclusive.[9] It comes from several sources. Most of the information is from the

[8] http://www.treasury.gov/resource-center/data-chart-center/tic/Documents/shla2012r.pdf

[9] The fact that our cross-listing sample is shorter by one year than the overall sample of our analysis is effectively intentional. Since we want to examine the liquidity risk sharing effects arising from cross-listing, for each listing event we need at least some observations occurring after the listing. That is, since our goal is to test what happens

Sarkissian and Schill public database that provides the geography of foreign listings from 1900s until 2006.[10] This is supplemented for more recent years with the listing information obtained directly from the main stock exchanges around the world, as well as CRSP records. We leave only those cross-listed U.S. firms in our sample that have identifiable permanent number (permno) in CRSP. The first identified cross-listing by a U.S. firm was in 1901 by USX Marathon Group, and it was placed in the Netherlands. Our total sample includes 293 firms with 570 cross-listings that span 20 foreign markets. 105 of those firms are traded in more than one foreign market.

Table 1 shows the distribution of cross-listings of U.S. firms abroad. Panel A gives their distribution across individual countries and decades. The largest number of foreign listing placements of U.S. firms was the 1980s – 180, with almost a third of them (65) being in Japan. This is almost twice as much as the second largest number over the decades of 1990s and 2000s. Note that while the number of cross-listings before 1960 (76) is comparable to that in each of the last two decades (92), the country representation is much more concentrated in the earlier part of our sample. Before 1960 U.S. firms were listed only in six markets with 75 listings occurring in Europe and only one in Canada. Yet, in the 2000s, U.S. firms were present already in 16 foreign markets with Canada becoming the preferred destination choice for U.S. companies. The recent presence of U.S. firms abroad is more dispersed across countries than even during the 1980s when they were traded only in ten foreign markets.

Panel B of Table 1 presents the distribution of U.S. firms listed abroad across countries and ten sectors based on the one-digit SIC codes. We can observe that more than 50% of all cross-listings belong to manufacturing companies, while agriculture, forestry, and fishing supplies only three listings, which are placed in resource-rich countries of Australia and Canada. Some countries tend to attract a disproportionately large number of U.S. firms from specific sectors. For example, 45% of mining firms are placed in Canada alone, 48% of transportation

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after U.S. firms list also abroad, the stock return and liquidity information in 2013 can be crucial for those firms listed in 2012.

[10] See http://sergei-sarkissian.com/data.html

firms are present Japan and the Netherlands, while more than 50% of financial firms are in Japan and the United Kingdom.

2.1. U.S. Firm Sample

We collect U.S. stock return and turnover data and construct the Amihud liquidity measure (Amihud, 2002) from CRSP daily stock dataset over the 1950-2013 period. The Amihud liquidity is based on the price impact and is computed as $-\log((10^6 \times |R_t|)/(PRC_t \times Vol_t))$, where PRC_t is the closing price of the stock, $|R_t|$ is the absolute value of stock return, and Vol_t is the trading volume at time *t*. The liquidity is then aggregated at the monthly frequency.

Table 2 reports the means, standard deviations, and the number of observations of stock returns, turnover, and liquidity of U.S. firms cross-listed abroad for each foreign market. Only the market of the first firm cross-listing is considered. The return is the annualized daily holding period return including dividends. The turnover is the percentage of the daily trading volume out of the total shares outstanding. All variables are winsorized at 1% and 99%. The grand mean return across all cross-listed firms is 16% per year. The top five foreign markets with the best U.S. firm performance are Brazil, Hong Kong, Austria, Israel, and Canada (with median annual return of 28%), while the bottom five are the countries of the Central and Northern Europe – Sweden, Belgium, the Netherlands, Switzerland, and Germany (with the median annual return of 14%). The average share turnover rate of cross-listed U.S. firms is 40% with those traded in Hong Kong and Australia reaching a rate in excess of 100%. On the other side, firms that are listed in the historically more established markets for overseas securities, such as Austria, Belgium, and the Netherlands, alongside with one firm placed in Brazil, have turnover of only about 30% or less. Finally, firms with higher liquidity are cross-listed first in such countries as Belgium, Hong Kong, Netherlands, Switzerland, and, surprisingly, Chile, while less liquid U.S.

firms are traded in Austria, Brazil, Canada, Israel, and Sweden.[11] We also want to note that we have more than two million daily observations for all three of our variables, but their numbers, as expected, vary greatly across markets. U.S. firms placed in the Netherlands have the highest count of data entries, while all 1,000 observations in Brazil come from only one firm.

3. Liquidity and Past Returns

3.1. Empirical Framework

In this section we investigate the relation between assets liquidity and past returns before and after listing abroad. We begin our analysis by aggregating the daily Amihud liquidity measure for each individual stock to average monthly Amihud liquidity, $LIQ_{i,t}$.[12] Then we compute the percentage change in this liquidity, $\Delta LIQ_{i,t}$, as $(LIQ_{i,t} - LIQ_{i,t-1})/LIQ_{i,t-1}$. Since our task is to evaluate the effects of lagged market returns on U.S. firm liquidity before and after cross-listing, we introduce a cross-listing dummy, $CL_{i,t}$, which equals one if an individual stock of firm *i* is listed in a foreign market at time *t*, and is zero otherwise.

Global financial markets are prone to various spillover effects that can greatly impact asset liquidity. Therefore, in our analysis we also include domestic and foreign market returns as additional explanatory variables, $R_{US,t}$ and $R_{IN,t}$, respectively. For the U.S. market return we use the CRSP total return index. However, computing the corresponding return in foreign markets is not straightforward. Since each firm not only can cross-list in different foreign markets but also can place its shares in various markets at the same time, there is no readily available proxy for the foreign markets return. In addition, the set of host markets for U.S. firms can also change through time. For example, the Apple Inc. was originally listed in Japan in the 1990s, while the American Express is originally listed in the U.K. in the 1970s. Years later, they both expanded

[11] The negative sign on the liquidity measure in Brazil is due to the properties of data coming from the only one U.S. cross-listed company in that country.
[12] During the aggregation process, we filter out the sample if there are less than 15 observations in a given month.

their foreign listings to Germany, in 1992 and 1993, respectively. Ideally, each U.S. firm i at a particular date t should have its distinct $R_{IN,t}$ based on the existing geography of its cross-listings at that time. Consistent with this logic and taking into account the complex nature of cross-listing reality, we construct the variable of foreign market returns, $R_{IN,t}$, as follows. Once a U.S. firm is cross-listed, the foreign market return is defined to be the an equally-weighted average of MSCI country index return for all host markets at time t.[13] For example, $R_{IN,t}$ for the Apple Inc. is the MSCI Japan index return from September 1990 to October 1992. After October 1992, the Apple Inc.'s $R_{IN,t}$ is the average of MSCI Japan index return and MSCI Germany index return. In this way, the foreign market return takes different values for each individual firm.

Our regression framework, similar to many studies on funding liquidity and market liquidity, is a variant of the empirical framework proposed by Hameed, Kang, and Viswanathan (2010). The regression model below relates the change in assets liquidity, $\Delta LIQ_{i,t}$, to the variables mentioned previously:

$$\begin{aligned}\Delta LIQ_{i,t} &= \alpha_i + \beta_1 R_{i.t-1} + \beta_2 R_{US,t-1} + \beta_3 R_{IN,t-1} + \phi CL_{i,t} + \gamma CL_{i,t} \times R_{US,t-1} + \lambda CL_{i,t} \times R_{IN,t-1} + \\ &+ FirmControls_{i,t-1} + MarketControls_{i,t-1} + FirmFE_i + \varepsilon_{i,t}\end{aligned}, \qquad (1)$$

This model differs from that in previous studies by allowing for cross-market interactions. Such effects are captured by slope coefficient β_3. A positive β_3 implies a contagious spillover effect on U.S. firms arising from equity market declines in foreign countries. Another important modification from the earlier work is that our regression focuses on the changes between pre- and post- cross-listing periods. These effects are captured by parameters γ and λ. A negative γ would imply that after cross-listing, the U.S. market decline causes a firm liquidity to deteriorate less than in the period before its listing on overseas exchanges. Therefore, in this case, international market participants act as net liquidity suppliers by providing liquidity to the U.S. market during its own downturns. At the same time, a positive λ would suggest that after cross-

[13] We also consider a scenario before a firm is cross-listed. In this case, to avoid any dramatic change to the foreign market returns variable, for a given U.S. firm, we define the foreign market return as the MSCI country index return of its first foreign market.

listing, U.S. firm liquidity becomes more vulnerable to negative foreign market shocks, and that international investors act as net liquidity demanders by intensifying the selling pressure in the United States at the time of foreign market declines.

Our Model (1) includes two sets of control variables. The first set includes two relevant for our analysis firms-specific characteristics, namely, the lagged changes in firm volatility, $\Delta\sigma_{i,t-1}$, and its individual shares turnover, $\Delta STOV_{i,t-1}$. These controls appear also in Hameed, Kang, and Viswanathan (2010) and are supported by the market microstructure studies.[14] The second set includes the same two variables estimated at the market level – for the United States and foreign countries. These are the lagged changes in the U.S. aggregate market volatility, $\Delta\sigma_{US,t-1}$, and its shares turnover, $\Delta STOV_{US,t-1}$, as well as international market volatility, $\Delta\sigma_{IN,t-1}$, and its shares turnover, $\Delta STOV_{IN,t-1}$. The U.S. market volatility is the monthly standard deviation of CRSP total market index returns. The international market volatility is the standard deviation of monthly foreign market returns. The aggregate U.S. market turnover is the equally-weighted share turnover of all firms listed in NYSE and NASDAQ. For each U.S. firm *i*, the aggregate international market turnover is the equally-weighted share turnover of all firms with the same host market as firm *i*.

3.2. Before and After Cross- Listing: Full Sample Tests

Table 3 reports the panel estimation results for various specifications of Model (1). It shows the individual coefficient estimates and their t-statistics (in parentheses), the number of observations in each regression and the adjusted R-squared. The standard errors are clustered by the host country for U.S firm cross-listings.[15] The intercept and host country fixed effects are included in each estimation but their coefficients are not reported. The first four columns of the table deal with the full data sample. Regression (1) contains only the first three independent

[14] See Stoll, (1978), Ho and Stoll (1980), Amihud and Mendelson (1986), Benston and Hagerman (1974), Chordia, Roll, and Subrahmanyam (2000) and others.

[15] We have also computed the standard errors clustered by firm and year, but these specifications do not materially change our estimated coefficients and their statistical significance. These results are available on request.

variables in Model (1), the lagged firm, U.S. market, and international market returns. Similar to Hameed, Kang, and Viswanathan (2010), we find positive and highly significant relations between firm liquidity and both its own return and domestic market return, implying the liquidity squeeze in poor firm or U.S. market conditions. In contrast, we observe no significant relation between U.S. firm liquidity and foreign market returns. This suggests a very limited influence of international markets on U.S. companies.

In Regression (2), we add the cross-listing dummy, $CL_{i,t}$, and two interaction terms, $CL_{i,t} \times R_{US,t}$ and $CL_{i,t} \times R_{IN,t}$. Now we observe that γ, one of the main coefficients of interest to us that shows the impact of the $CL_{i,t} \times R_{US,t}$ term on firm liquidity, is negative and significant at the 1% level. This means that during negative U.S. market performance, the liquidity of U.S. firms that are cross-listed in foreign markets declines less than when these firms were listed solely on U.S. exchanges. Yet, another coefficient of our interest, λ, shows that the $CL_{i,t} \times R_{IN,t}$ term is not significant, implying that U.S. firm exposure to direct trading in foreign markets does not diminish its liquidity at times of negative foreign market returns. The previously observed positive relations between firm liquidity and its own and U.S. market returns remain intact.

In Regressions (3) and (4) we subsequently include the two firm-level controls and then, in addition, our four market-level control variables. Consistent with previous studies (Amihud and Mendelson, 1986; Benston and Hagerman, 1974; Chordia, Roll, and Subrahmanyam, 2000), we find that the lagged changes in both firm volatility and individual share turnover are significant drivers of its liquidity. Increases in volatility and decreases in share turnover both reduce firm liquidity. The inclusion of market-level controls further shows that only changes in aggregate volatility have a statistically important linkage to firm liquidity: as expected, increases in volatility in both the United States and around the world negatively affect individual firm liquidity. However, the inclusion of all these controls does not qualitatively change our conclusions with respect to coefficients γ and λ. As before, we see that after cross-listing U.S. firms experience much less liquidity decrease during domestic market declines, while their liquidity is unaffected when negative return shocks hit international markets. In addition, note that firm-level controls significantly increase the overall explanatory power of the regression: The adjusted R-squared increases from 1.5% in Regressions (1-2) to 22% in Regression (3). The subsequent inclusion of market-level controls practically leaves the R-squared unaffected.

Regressions (5) and (6) are again estimated on the full model but on the two 32-year sub-periods of our sample, from 1950 to 1981 and from 1982 to 2013, respectively. These tests show that all the results obtained on the overall data sample hold in these sub-samples as well. We specifically want to note that there is no reduction in the economic or statistical significance of the coefficient on $CL_{i,t} \times R_{US,t}$ between the two periods.

It is also important to compare coefficients β_2 and γ, that is, the slopes on $R_{US,t}$ and $CL_{i,t} \times R_{US,t}$ terms. The last raw in Table 3 performs the F-test that the sum of these two coefficients is zero, reporting also the corresponding p-values. We can see that for the full sample $\beta_2 + \gamma$ is statistically indistinguishable from zero in Regressions (2-4), implying that the liquidity provision by international markets effectively offsets the reduction in firm liquidity resulting from U.S. market declines. The sum of β_2 and γ is also statistically zero for the second 32-year sub-period of our sample, indicating that cross-listed U.S. firms achieve deeper liquidity risk reduction benefits in more globalized financial markets (e.g., see Carrieri, Errunza, and Hogan, 2007). Thus, on average cross-listings help U.S. firms maintain their level of liquidity even during U.S. market underperformance.

3.3. Before and After Cross- Listing: Sub-Sample Tests

Having established an overall strong positive relation between cross-listing placement and U.S. firm liquidity, our next step is to analyze how this relation changes under different market conditions at home and how it is impacted by the characteristics of foreign markets. We report the results of these tests in Table 4. Across all estimations in this table we use the full set of controls variables. As before, the intercepts and firm fixed effects are also included in each regression, and standard errors are clustered by foreign markets. In Panel A we re-estimate Model (1) across different U.S. market return and volatility regimes. The first and second columns show the sample split by the below median and above median U.S. monthly market return, respectively. We observe that coefficient γ on $CL_{i,t} \times R_{US,t}$ is negative and highly significant in both specifications, but it is more than 50% larger in absolute values in weak U.S. markets. This implies a larger relative support for U.S. firm liquidity coming from international markets in periods of U.S. market-wide underperformance than when local conditions are strong. In columns 3 and 4 of the panel, we split the U.S. return sample based on the bottom 25% and top 25% of monthly performance. The test results are very similar in both qualitative and quantitate terms to those in the first and second columns, respectively. In the last two columns of the panel we split the U.S. market by its median aggregate volatility (below median in column 5 and above median in column 6). Higher market volatility on average is associated with more uncertainly and more propensity for liquidity dryout (e.g., Chordia, Sarkar, and Subrahmanyam, 2005). Consistent with this notion, the coefficient on $R_{US,t}$ is almost twice larger when U.S. market volatility is high than when it is low. Consequently, and similar to previous results in this panel, γ is also 50% larger in more uncertain times for the U.S. market.

Thus, Panel A of Table 4 shows that cross-listings provide the largest liquidity benefits to U.S. firms in poor U.S. market conditions, that is, exactly at times when investors need liquidity the most. These liquidity gains are much larger in economic terms than potential liquidity reduction that cross-listings may induce in stronger U.S. markets.

In Panel B of Table 4, we examine how the characteristics of foreign markets influence the documented positive relation between cross-listings and liquidity provision to U.S. firms in negative U.S. markets. We consider three characteristics: the number of host markets with trading of a given U.S. firm, foreign market liquidity, and foreign market capitalization.[16] The market liquidity is the zero-return measure of Lesmond, Ogden, and Trzcinka (1999), and it comes from Goyenko and Sarkissian (2014). It is the equally-weighted average proportion of zero daily returns across all firms in a given country from 1977 to 2010. The host market

[16] Strictly speaking, the number of foreign markets that a given firm's stock is trading is more suitable for a firm-specific characteristic. However, since the properties of foreign markets can impact the cross-listing-liquidity relation that we examine, their number can too.

capitalization information is from the World Development Indicators (WDI) database at the World Bank. Intuitively, trading across a larger set of foreign markets should lead to more liquidity supply to U.S. companies during market turmoil as long as global markets do not strongly move to negative grounds in unison. Similarly, we should expect that more liquid markets and market with larger market capitalization and, therefore, larger potential investor pools, to be more effective sources of liquidity propagation to U.S. firms through their shares listed in those markets.

The first and second columns of Panel B show the impact of cross-listing on U.S. firm liquidity when the firm is placed in only one foreign market and when is it placed in multiple markets, respectively. Consistent with economic intuition, we observe a much stronger liquidity supply to those firms that are listed on multiple foreign exchanges: coefficient γ is more than 60% larger in absolute value for firms that are cross-listed in two or more countries than for those present on only one overseas exchange. The third and fourth (fifth and sixth) columns of the panel show the cross-listing impact for firms traded in low and in high liquidity (market capitalization) markets, respectively. The sample splits for both these market characteristics are based on the median. The estimation results are again aligned with expectations: countries with high aggregate liquidity or larger financial markets channel at least 50% more liquidity to U.S. firms listed on their exchanges than countries with below median values of liquidity and size.

One may assume a strong positive relation between countries with larger market capitalization and those with more liquid markets implying an irrelevance of splitting the foreign country sample by either their liquidity or their market size. However, Figure 1 shows that it is not generally the case. It depicts the average market liquidity versus the average market capitalization for all 20 countries in our sample that host U.S. firm shares. For the ease of understanding, we denoted the countries by their respective two-letter codes. For example, the financial markets of France and Canada are about the same size, but their liquidity is drastically different. On the other side, even though the market capitalization of Japan is more than four times larger than that of the Netherlands, the market-wide liquidity is very similar in both countries.

Next, in a manner similar to our tests in Table 4, we proceed to analyzing how firm cross-listings impact their liquidity depending on various firm-specific characteristics. The firm characteristics that we consider are: the probability of informed trading (PIN), total volatility, and the proportion of foreign income. We collect all firm-specific information at the end of each year and average over the whole sample period. The PINs are calculated using the methodology of Venter and Jongh (2006). Firm volatility is the standard deviation of firm gross returns over the sample period. Foreign income is the proportion of the firm's foreign pretax income out of the total pretax income. We focus on these three characteristics because of their relevance for firm liquidity. We already discussed the link between firm liquidity and volatility. Furthermore, Easley, et al. (1996) introduce the PIN measure and link it to stock liquidity. Stocks with high PIN receive less liquidity provision, and, therefore, would suffer more during liquidity crisis. By listing on an overseas exchange, a firm attracts additional noisy traders from the foreign country making its stock more amenable for liquidity providers. As a result, we can expect more benefits for stocks with high PIN. Grullon, Kanatas, and Weston (2004) show that higher firm visibility improves its liquidity. Since a firm's foreign operations improve its overall visibility, one should expect greater liquidity benefits upon cross-listing among firms with high foreign income.[17]

Table 5 reports Model (1) results across firm characteristics sub-samples, each of which is split at the median. In every regression, as before, we use the full set of controls variables, do not show the intercepts and firm fixed effects, and cluster standard errors by foreign markets. Consistent with expectation, we find much stronger cross-listing effect on firm liquidity innovations among firms with high PIN, high volatility, and high foreign income: their coefficients on the interactive term $CL_{i,t} \times R_{US,t}$ are larger by about 150%, 50%, and 60% than the corresponding estimates for firms with low PIN, low volatility, and low foreign market income.

[17] Note that such standard firm attributes as book-to-market ratio, earnings per share, leverage do not have a clear relation to firm liquidity.

3.2. Cross-Listings and the Matched Sample

Our previous results indicate substantial benefits in liquidity level maintenance among cross-listed U.S. firms relative to their own past when they were traded only on U.S. stock exchanges. Note from Table 1 that more firms became cross-listed over the course of our sample period, which coincides with an increased cross-market market openness and globalization trends. Therefore, we may not exclude the possibility that all or the main part of liquidity gains that we associate with cross-listing placements are driven not by cross-listings themselves but by that general upward trend in global market integration that mitigates liquidity constraints among U.S. firms towards the end of our sample period.

To alleviate this concern, we need to compare how changes in firm liquidity are related to past firm, U.S., and foreign market returns not only for cross-listed firms, but also for other comparable U.S. firms that are traded solely in the United States. Simply looking at the sample of all non-cross-listed firms is not sufficient since their average properties can be different from those of cross-listed firms. Therefore, we consider a sample of U.S. firms without cross-listings that includes only those firms that constitute the best possible match with our existing cross-listing firm sample. We construct the matched sample using Heckman, Ichimura, and Todd (1997) methodology based on three firm characteristics, book-to-market ratio, leverage ratio, and market capitalization, as well as the same four-digit SIC industry classification as the cross-listed company.

We collect the accounting information for all firms from Compustat and the stock market information from CRSP. All firm characteristics are collected at the end of each year and averaged over the sample period. Book-to-market ratio is computed as firm's book value of equity divided by the market value of equity. Leverage ratio is the long-term debt divided by the sum of long-term debt and market value of equity. Market capitalization is the logarithm of firms' total dollar market value of all outstanding common shares. The matched sample is constructed using the propensity score matching technique as follows. Using logistic regressions, we compute the propensity score for all non-cross-listed firms with the same four-digit SIC code as the cross-listed ones. The cofounders in the logistic regressions include book-to-market ratio, leverage ratio, and market capitalization. Then, for each U.S. firm with a cross-listing, we select two control firms with the closest propensity score to the cross-listed firm. We follow Dehejia and Wahba (2002) and conduct matching with replacement, that is, we allow one firm to be matched with multiple cross-listed firms during the matching process.

Table 6 reports the summary statistics of firm characteristics for U.S. firms with cross-listings, all U.S. firms without cross-listings, and the matched sample of non-cross-listed U.S. firms. (The U.S. firm sample without cross-listings has the same four-digit SIC codes as cross-listed firms and is reported for information purposes only.) The table shows the number of observations, the means and standard deviations, as well as the minimum and maximum values for each firm characteristic in each of the three samples. The sample period is still 1950-2013. However, in this table, the sample of cross-listed firms includes only those cross-listed U.S. firms that have valid links between CRSP and Compustat fundamental and supplemental data. We identify 281 cross-listed firms with all the necessary financial accounting data, 8,548 firms without cross-listings, and 545 firms without cross-listings in the matched sample. The mean of the first firm attribute, the book-to-market ratio, is remarkably similar across all three samples, ranging between 0.70 and 0.72. The average leverage ratio is lower among cross-listed firms than all non-cross-listed firms, but it is closer to that of the matched sample of non-cross-listed firms. Similarly, the average size of cross-listed firms is much larger than the corresponding statistics for the all non-cross-listed sample, but it is again substantially closer to the matched firm sample. The remaining difference in the average firm size between the cross-listed sample and the matched sample (8.2 and 7.0 in log terms, respectively) is not surprising since cross-listed firms tend to be large, and it is hard to match them perfectly from the remaining pool of available firms. However, the standard deviation of firm size is almost the same for both the cross-listing and the matched samples. Thus, Table 6 shows that the matched sample of U.S. firms with no foreign listings that we want to examine vis-à-vis the firm sample with cross-listings possesses comparable to the later sample characteristics.

The regression model that we use for the cross-sample estimation is the reduced version of Model (1) without all the terms that include the cross-listing dummy, namely:

$$\begin{aligned}\Delta LIQ_{i,t} &= \alpha_i + \beta_1 R_{i.t-1} + \beta_2 R_{US,t-1} + \beta_3 R_{IN,t-1} + \\ &+ FirmControls_{i,t-1} + MarketControls_{i,t-1} + CountryFE_i + \varepsilon_{i,t}\end{aligned}, \quad (2)$$

where all the controls variables are the same as in Model (1). The main coefficient of interest to us in this model is β_2. If cross-listings of U.S. firms reduce the negative impact of U.S. market downturns on their liquidity, then we should observe that the slope on $R_{US,t}$ for cross-listed firms is substantially lower than that of the matched sample. In addition, we should observe no statistical differences in these coefficients between the matched sample and cross-listed firms prior to their listing abroad.

Table 7 presents the test results based on Model (2) using the samples of cross-listed firms (columns 1-3) and the matched sample of non-cross-listed firms (columns 4-6). For each firm sample, we also estimate Model (2) for the periods before and after the cross-listing. For cross-listed firms, the periods before and after cross-listing are categorized by the initial foreign listing date. For each firm in the matched sample, we set its pseudo initial foreign listing date to be the same as its corresponding cross-listed firm. The reported and omitted information is similar to that in Tables 3-5. The last two rows of the table report two Chi-squared tests with the corresponding p-values. The first tests whether the coefficients on $R_{US,t\text{-}1}$ are statistically different after and before the initial foreign listing date ($R_{US,After} = R_{US,Before}$). The second tests whether the coefficients on $R_{US,t\text{-}1}$ are statistically different between cross-listed firms and firms from the matched sample ($R_{US,CL} = R_{US,MS}$).

We make several important observations. First, we find that the average impact of $R_{US,t\text{-}1}$ on liquidity innovations is much smaller for cross-listed firms than for the matched ones. Second, similar to our previous results in Table 3, we find that negative U.S. market return leads to much smaller reduction in liquidity for cross-listed firms after their actual initial cross-listing event. The Chi-squared test shows that this difference is highly significant. In contrast, the difference in the respective estimates before and after the pseudo initial cross-listing date for matched firms is practically zero both economically and statistically. Third, the relative magnitude of the coefficient on $R_{US,t\text{-}1}$ before cross-listing for both firm samples is almost the same (0.29 and 0.27). This implies that our matched sample of firms behaves very similar to the main cross-listed firm sample also in terms of the impact of its returns on firm-specific liquidity changes. However, the after cross-listing tests reveal a drastic difference between the two samples. Now, the coefficient on $R_{US,t\text{-}1}$ for cross-listed firms is more than 50% smaller than that for the matched ones. Not surprisingly, this difference is also highly significant, as illustrated by the corresponding Chi-squared test. Fourth, note that even the coefficient on the lagged firm return, $R_{i,t\text{-}1}$, for cross-listed firms is substantially lower after the listing for the cross-listed sample of firms. Finally, we observe that international market returns do not materially influence U.S. firm liquidity, irrespective whether a firm does or does not have a foreign listing. Thus, Table 7 provides another piece of evidence that foreign listings, reflecting unsynchronized funding constrains in global markets, provide unique liquidity benefits to U.S. firms.

4. Liquidity Provision and Return Reversal

While we have already shown that U.S. firms are able to maintain their liquidity in adverse home market conditions if they are cross-listed on foreign exchanges, we do not have yet information on how the enhanced firm liquidity affects its return dynamics. We expect, in particular, that due to their higher liquidity cross-listed firms suffer less from transitory price shocks. Therefore, these firms should experience weaker return reversals after cross-listing than comparable firms without presence on foreign exchanges. That is, the *change* in temporary price deviations for cross-listed firms should be greater than that for their counterparts listed only domestically on U.S. exchanges relative to their respective pre-listing periods (pre-quasi-listing period for U.S. only listed firms). [18]

We address this issue by applying the liquidity provision strategy framework as in Lehman (1990), Lo and MacKinlay (1990), and Nagel (2012). The liquidity provision trading strategy specifies the portfolio weight for stock *i* at time *t* as

$$w_{i,t} = -\left(1/2\sum_{i}^{N} | R_{i,t-s} - R_{m,t-s} |\right)^{-1} (R_{i,t-s} - R_{m,t-s}) , \tag{3}$$

where $R_{m,t-s}$ is the *s*-period lagged daily equally-weighted market index return, $R_{i,t-s}$ is the *s*-period lagged daily gross return of firm *i*, and *N* is the total number of stocks in the portfolio. In effect, the difference $R_{i,t-s} - R_{m,t-s}$ shows how different the firm return is from the market index at some lag *s*. The portfolio return at time *t* for the liquidity provision trading strategy is calculated as

$$\Pi_{s,t} = -\left(1/2\sum_{i}^{N} | R_{i,t-s} - R_{m,t-s} |\right)^{-1} \sum_{i=1}^{N} (R_{i,t-s} - R_{m,t-s}) R_{i,t} . \tag{4}$$

Then we compute the weekly portfolio return for $s = 1, 2\ldots, 5$ over the sample period as

$$\Pi_{t} = \sum_{s=1}^{5} \Pi_{s,t} . \tag{5}$$

Table 8 shows the estimation results. It reports the mean, μ, standard deviation, σ, and autocorrelation, ρ, of aggregated portfolio returns, Π_t, before and after the cross-listing. The last two columns of the table compute the difference in mean returns, $\mu_{Before} - \mu_{After}$, with the corresponding t-statistic based on the two-sample *t*-test. Panel A reports the weekly portfolio returns for cross-listed firms versus the matched sample before and after the listing (pseudo listing dates for the matched sample). The matched sample is the same as in Table 6. The means

[18] Indeed, cross-listed firms may have weaker return reversals for many reasons other than the presence in overseas markets (e.g., relatively larger size). Therefore, estimating the return reaction from liquidity provision before and after the cross-listing event is crucial.

of weekly return reversals before the listing for the cross-listed and the matched samples of firms are 1.22% and 0.75%, respectively, and the same means after the listing are 1.11% and 0.48%. While return averages are statistically smaller after the listing for both firm samples, as seen from the corresponding values of the t-statistic, the reduction in the weekly return reversal magnitude is markedly lower for cross-listed firms. In economic terms, cross-listed firms achieve a 2.5 larger reduction in temporary return deviations than similar firms without foreign listings. Note that the cross-sample decrease in the severity of return reversals after cross-listing is likely to be driven by increasing market integration in the last decades.

Panel B reports the weekly portfolio returns categorized by three foreign market characteristics and three firm-specific characteristics for the sample of cross-listed firms only. Each of the two rows in Panel B reports the portfolio return of sub-samples based on the median-split. The first three sub-panels show portfolio returns grouped by the number of markets for firm listings, market liquidity, and market capitalization. We can see that the average return reversal is reduced after the listing for all sub-samples of foreign markets. However, both economically and statistically, this reduction is much stronger for multiple foreign markets, and markets with high liquidity and market capitalization. Relative to the pre-listing magnitudes, these reductions constitute, respectively, 51% (0.277/0.543), 37% (0.211/0.577), and 52% (0.282/0.538). The last three sub-panels of Panel B show portfolio returns grouped by PIN, total volatility, and foreign income. In these set of tests the mean return reversal difference, $\mu_{Before} - \mu_{After}$, is statistically zero for firms with low volatility and low foreign income, while it is only marginally significant for low PIN firms. In contrast, firms with high values of PIN, volatility, and foreign income post much more significant drops in the magnitude of weekly return reversals after the listing as compared to that before the listing. In economic terms these reductions constitute, respectively, 16% (0.145/0.930), 13% (0.120/0.918), and 40% (0.278/0.701) of the original return reversal magnitudes.

Thus, Table 8 illustrates that, due to higher liquidity provision, cross-listings yield sizable benefits to stock returns of U.S. firms with their shares trading also abroad. The impact of transitory price shocks to firms with cross-listings is not as severe as that to firms without any presence on foreign stock exchanges. The cross-sectional patterns in the extent of these cross-listing benefits across foreign market and firm characteristics are similar to the patterns in the cross-listing impact on liquidity innovations discussed in Tables 3-5.

5. Liquidity Risk

In previous sections we have shown significant improvement to U.S. firm liquidity in U.S. market downturns when firms are listed on foreign exchanges and that cross-listed firm shares have much faster and less severe return reversals from transitory price shocks. What remains to be understood is how different the liquidity risk of cross-listed stocks is from that of similar but non-cross-listed firms. To accomplish this, we need to deal with a counter-sample of non-cross-listed firms that is most identical to the cross-listed one. Note that the matched sample of cross-listed firms that we used in Section 3 may have larger liquidity betas simply by construction. Indeed, recall that we matched it with the cross-listed sample by the four-digit SIC codes and three firm-level characteristics. However, since cross-listed firms are usually the largest and most liquid firms in a given industry, our previously matched sample would have absorbed less liquid competitors of cross-listed firms. As a result, it could yield larger liquidity betas.[19] Therefore, in this section, we draw both the cross-listed and the matched non-cross-listed firm samples from the S&P 500 index, and the next figure illustrates our rationale.

Figure 2 shows the proportion of cross-listed stocks in the S&P 500 index from 1950 to 2013. It shows this proportion based on (i) the number of listed firms, and (ii) market capitalization. The market capitalization data and the S&P 500 index constituents' information are from CRSP. Plot A reports the two proportions of firms with cross-listings out of the S&P 500 index constituents. Note that the spikes in the two series in 1957 were due to the S&P 500

[19] Acharya and Pedersen (2005) confirm that small firms have large liquidity betas. This result is similar across all three liquidity betas.

index foundation on March 4 of that year. Prior to 1957 our proxy for the S&P 500 index is based on the S&P 100 index. We can see that the proportion of cross-listed firms in the S&P 500 index steadily increased until the 1990s reaching about 30%. Towards the end of our sample period only 20% of S&P 500 firms were cross-listed. Yet, the proportion of the market capitalization of cross-listed firms in the index is remarkably similar throughout the whole sample period staying on average at about 50% level.

Plot B of Figure 2 depicts the two proportions of cross-listings included in the S&P 500 index out of the entire sample of cross-listings. The proportion of cross-listed firms within the index was about 90% after 1957 up until the late 1990s. Since then it dropped to about 60% level by 2013. In spite of these swings in the number of cross-listed firms in the S&P 500 index, the proportion of the market value of cross-listed firm in the index is hovering close to 100% from 1957 onwards. Thus, most of cross-listed firms are included in the S&P 500 index and they constitute half of the market value of the S&P 500 index. This means that the S&P 500 index represents a natural sample to compare liquidity risk of cross-listed and non-cross-listed firms.

Following Acharya and Pedersen (2005), we consider three liquidity betas, $\beta(Liq_i, Liq_m)$, $\beta(Liq_i, r_m)$, and $\beta(r_i, Liq_m)$. For each firm *i*, we fit the following bivariate model to obtain the three liquidity betas:

$$y_{i,t} = \alpha_i + \beta_i x_{i,t} + \varepsilon_{i,t}\,,\ \varepsilon_{i,t} \sim N(0, \sigma_i^2)\,, \tag{5}$$

where (y_i, x_i) can take a form of (Liq_i, Liq_m), (Liq_i, r_m) and (r_i, Liq_m). Liq_i is the innovation of firm *i*'s monthly Amihud liquidity measure, obtained from the estimated residuals in the univariate AR(2) model. Liq_m is the innovation of monthly market aggregated Amihud liquidity measure obtained from the estimated residuals in the univariate AR(2) model. The market aggregated Amihud liquidity measure is the equally-weighted Amihud liquidity measure of all firms listed in NYSE and NASDAQ. r_i and r_m are the monthly excess returns of firm *i* and CRSP U.S. total market index over the one-month Treasury bill rate, respectively.

Table 9 reports the summary statistics of estimated liquidity betas for cross-listed U.S. firms and S&P 500 firms without foreign listings over the full sample period. The sample of cross-listed U.S. firms includes U.S. firms with foreign listings after their initial foreign listing date. The sample of S&P 500 index firms excluding cross-listings consists of the S&P 500 constituents without foreign listings. This sample is reconstructed after each change in the constituents of the S&P 500 index. To be included in our sample, we also require a firm to have at least 12 months of return and liquidity history available. The two-sample difference test is reported in the last column with the corresponding t-statistic. We can see that both $\beta(Liq_i, Liq_m)$ and $\beta(Liq_i, r_m)$ are significantly lower for cross-listed firms. This implies that the liquidity of U.S firms with foreign listings is much less sensitive to both U.S. stock market liquidity and U.S. stock market returns than firms with no presence on overseas exchanges. The only liquidity beta that is economically and statistically indistinguishable between the two firm samples is $\beta(r_i, Liq_m)$.

The traditional two-sample t-test requires (i) the assumption of normality and (ii) a large number of observations. First, the Jarque-Bera test, not reported here, shows that the estimated liquidity betas have fat tails. Second, Kruschke (2012) finds that the standard t-test achieves reasonable power only for sample sizes in excess of 1,000, but we have less than 300 observations. Therefore, we also perform an alternative estimation of three liquidity betas using Bayesian methods following Casella and George (1992), Gonen et al. (2005), and Kruschke (2012). The liquidity betas are assumed to be independent and identically distributed (i.i.d.) draws from a *t*-distribution with different means, μ_1 and μ_2, and standard deviations, σ_1 and σ_2, for each population, and with a common normality parameter, ν. The priors of these parameters are assumed to be minimally informative: normal priors with large standard deviation for μ_k, broad uniform priors for σ_k, and a shifted-exponential prior for ν, where $k = 1, 2$. Given the observed liquidity betas β_i for each firm i, the Bayesian inference then reallocates credibility of the combination of values $\{\mu_1, \mu_2, \sigma_1, \sigma_2, \nu\}$ in the model as $\Pr(\mu_1, \mu_2, \sigma_1, \sigma_2, \nu \mid \beta_j)$. The posterior distribution of $\{\mu_1, \mu_2, \sigma_1, \sigma_2, \nu\}$ is approximated by generating a large representative sample through the Markov Chain Monte Carlo (MCMC) methods and Gibbs sampling algorithm.

Table 10 reports the results of the Bayesian two-sample *t*-tests based on the liquidity betas of cross-listed U.S. firms and the S&P 500 index firms without foreign listings. The reported statistics of the MCMC samples for the posterior distributions of $\{\mu_1, \mu_2, \sigma_1, \sigma_2, \nu\}$ include the differences between the sample means, $\mu_1 - \mu_2$, and standard deviations, $\sigma_1 - \sigma_2$. HDI denotes the 95% Highest Density Interval, also known as the Bayesian confidence interval. We can observe that both lower and upper HDI bounds for the difference in means, $\mu_1 - \mu_2$, for the first two liquidity betas, $\beta(Liq_i, Liq_m)$ and $\beta(Liq_i, r_m)$, are negative. This implies that the averages of these two liquidity betas are significantly lower for the sample of cross-listed firms. Moreover, both lower and upper HDI bounds for the difference in standard deviations, $\sigma_1 - \sigma_2$, are also negative for these betas. Therefore, $\beta(Liq_i, Liq_m)$ and $\beta(Liq_i, r_m)$ are not only smaller for the cross-listed U.S. firms but also less volatile than the corresponding measures for the non-cross-listed sample of S&P 500 firms. As before, we do not find significant differences in the average values of $\beta(r_i, Liq_m)$ between the two samples. Therefore, the results in Tables 9 and 10 illustrate that the sensitivity of firm liquidity to negative shocks to both aggregate liquidity and market returns is substantially reduced among firms the shares of which are present on foreign exchanges.

In a static setting of the previous two tables, we observed differences in the average liquidity betas between firms with and without foreign listings. However, it is known that liquidity and liquidity risk can show time variation (e.g., Engel and Lange, 2001; Watanabe and Watanabe, 2008). Therefore, it is also necessary to understand whether the difference in liquidity betas between the two firm samples is also present through time. For this purposes, we follow Watanabe and Watanabe (2008) and estimate liquidity betas from a regime switching model with time-varying transition probabilities. The regime switching model is described as follows:

$$y_{i,t} = \alpha_{i,s_t} + \beta_{i,s_t} x_{i,t} + \varepsilon_{i,t}, \ \varepsilon_{i,t} \sim N(0, \sigma^2_{i,s_t}),$$

$$\Pr(s_t = s \mid s_{t-1} = s, STOV_{t-1}) = \Phi(c_{s_t} + d_{s_t} \cdot STOV_{t-1}), \tag{6}$$

where s_t = 1, 2 is the state at time t, α_{s_t} β_{s_t} $\sigma^2_{s_t}$ are the intercept, liquidity betas, and variance of the innovation at state s_t, respectively, $STOV_{t-1}$ is the lag of de-trended aggregate share turnover, and $\Phi(\cdot)$ is the cumulative density function of the standard normal distribution. Each pair (y_i, x_i) takes a form of (Liq_i, Liq_m), (Liq_i, r_m), or (r_i, Liq_m) as in model (3).

Table 11 shows the estimation of time-varying liquidity betas of cross-listed U.S. firms and S&P 500 firms without foreign listings. It also shows the chi-square statistics and the corresponding p-values (in square brackets) for the likelihood ratio tests, LR Tests, on various parameter restrictions. The first three rows test whether the parameters are time-varying. We can see that there is strong evidence of time-variation in most of the parameters of model (4), with the exception of the intercept. The residual volatility is time-varying across all but one liquidity beta for the S&P index sample. More importantly, there is also evidence of strong time-variation in two liquidity betas of cross-listed firms, $\beta(Liq_i, Liq_m)$ and $\beta(r_i, Liq_m)$, and in all three liquidity betas of non-cross-listed firms from the S&P index. Furthermore, the point estimates of $\beta(Liq_i, Liq_m)$ and $\beta(Liq_i, r_m)$ for cross-listed firms appear to be markedly lower than the corresponding estimates for the sample of non-cross-listed firms in both states. Therefore, the sensitivity of firm liquidity to market liquidity and returns among cross-listed firms is lower at times of both high and low market turnover. The last row tests the null hypothesis that the difference in liquidity betas between the two states is statistically identical for cross-listed U.S. firms and for the S&P 500 firms without foreign listings, i.e., $\beta_{1,CL} - \beta_{2,CL} = \beta_{1,SP} - \beta_{2,SP}$. (Another way to interpret this result is that whether the betas (both high and low state) are jointly identical between cross-listed firms and S&P 500 index firms without foreign listings, i.e., whether $\beta_{1,CL} - \beta_{1,SP} = \beta_{2,CL} - \beta_{2,SP}$.) It reveals that cross-listed firms have not only lower average and individual state-level $\beta(Liq_i, Liq_m)$ and $\beta(Liq_i, r_m)$, but also lower change in these two liquidity risks when market moves from a low turnover to a high turnover state. Only the sensitivity of firm returns to market liquidity, $\beta(r_i, Liq_m)$, appears to be statistically similar between the two firm samples.

6. Conclusions

In this paper, using a sample of U.S. firms cross-listed abroad since 1901 and with stock return and liquidity data between 1950 and 2013, we study the impact of international markets on firms' liquidity risk. This framework offers us at least two advantages. First, we examine the liquidity dynamics of firms from a domestic market with the most comprehensive data on stock returns and liquidity. Second, we estimate the impact of variations in investor trading preferences and margin constrains across countries on firm liquidity under practically identical firm-level conditions with the exception of the stock trading venue(s).

We find that the presence of firm shares on foreign exchanges help maintain firm liquidity during U.S. market downturns. The positive influence of foreign-traded shares on firm liquidity is particularly profound when U.S. firms are cross-listed in multiple foreign markets, in markets with high capitalization and high aggregate liquidity. Firms with such characteristics as high volatility, high foreign income, and high probability of informed trading also receive additional liquidity benefits from foreign listing placements. Furthermore, because of higher liquidity of cross-listed firms, transitory shocks affect their returns less than those of non-cross-listed firms. Finally, the analysis of liquidity betas shows that the sensitivity of firm liquidity to aggregate U.S. market returns and aggregate liquidity is significantly lower among cross-listed firms than among comparable firms with no presence in overseas stock markets. Therefore, our analysis provides evidence for an important role of international markets for global liquidity provision and risk sharing.

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Table 1: Distribution of U.S. firms cross-listed abroad

Panel A: Distribution of U.S. firm cross-listings across time

Country	afore 1960	1961-1970	1971-1980	1981-1990	1991-2000	2001-2012	Total
Australia	0	0	0	1	6	4	11
Austria	0	0	1	0	1	1	3
Belgium	17	7	5	3	3	0	35
Brazil	0	0	0	0	1	0	1
Canada	1	1	4	5	11	41	63
Chile	0	0	0	0	0	16	16
France	4	13	7	14	5	6	49
Germany	0	0	1	4	36	1	42
Hong Kong	0	0	0	0	0	1	1
Israel	0	0	0	0	0	6	6
Japan	0	0	11	65	3	1	80
Luxembourg	0	0	0	0	1	0	1
Mexico	0	0	0	0	0	1	1
Netherlands	39	8	1	21	4	4	77
Norway	0	0	0	0	1	1	2
Peru	0	0	0	0	1	0	1
Romania	0	0	0	0	0	1	1
Sweden	0	0	0	1	5	1	7
Switzerland	13	10	20	20	5	2	70
U.K.	2	11	30	46	9	5	103
Total	76	50	80	180	92	92	570

Table 1 (continued)

Panel B: Distribution of U.S. firm cross-listings across industries

Country	AGR	MNG	MFC	TSP	TRD	FIN	SVC	ADM	Total
Australia	1	3	6	0	0	0	1	0	11
Austria	0	0	1	0	0	0	2	0	3
Belgium	0	5	22	3	0	2	2	1	35
Brazil	0	0	0	0	1	0	0	0	1
Canada	2	34	14	3	3	5	2	0	63
Chile	0	3	5	1	1	3	2	1	16
France	0	4	30	2	3	8	1	1	49
Germany	0	1	31	4	1	3	2	0	42
Hong Kong	0	0	1	0	0	0	0	0	1
Israel	0	0	3	1	0	0	2	0	6
Japan	0	3	42	13	4	14	3	1	80
Luxembourg	0	0	1	0	0	0	0	0	1
Mexico	0	0	0	0	0	1	0	0	1
Netherlands	0	6	40	17	6	3	4	1	77
Norway	0	0	1	1	0	0	0	0	2
Peru	0	1	0	0	0	0	0	0	1
Romania	0	0	1	0	0	0	0	0	1
Sweden	0	1	4	1	0	0	1	0	7
Switzerland	0	9	39	10	3	5	3	1	70
U.K.	0	7	51	13	4	19	8	1	103
Total	3	77	292	69	26	63	33	7	570

This table provides the distribution of U.S. firms cross-listed aboard from 1901 to 2012 inclusive. Panel A show the distribution of listings across countries and time, while Panel B presents the distribution of U.S. cross-listed firms across countries and nine industries: AGR – Agriculture, Forestry, and Fishing; MNG – Mining and Construction; MFC – Manufacturing; TSP – Transportation; TRD – Wholesale and Retail Trade; FIN – Finance, Insurance and Real Estate; SVC – Services; and ADM – Public Administration. Industries are classified based on one-digit SIC codes. The cross-listing data come from several sources: the Sarkissian and Schill public foreign listing database, listing information from the major stock exchanges of each country, and CRSP.

Table 2: Descriptive statistics of U.S. firms cross-listed abroad

	Mean			Standard Deviation			Observations		
	Return	Turnover	Liq	Return	Turnover	Liq	Return	Turnover	Liq
Australia	0.193	1.089	5.446	0.523	3.287	2.695	34,024	33,211	29,966
Austria	0.275	0.318	1.146	0.662	0.718	2.195	5,071	5,071	4,227
Belgium	0.135	0.318	6.782	0.314	0.516	2.800	85,207	85,207	79,262
Brazil	0.375	0.226	-1.348	1.039	0.538	2.073	1,469	1,469	949
Canada	0.200	0.547	4.394	0.537	1.154	3.369	239,542	234,410	197,372
Chile	0.238	0.964	8.882	0.358	2.231	3.434	15,898	15,898	15,055
France	0.179	0.425	6.236	0.366	1.376	3.190	169,916	163,125	143,921
Germany	0.153	0.468	4.960	0.470	1.250	2.604	51,573	51,573	47,723
Hong Kong	0.341	1.244	8.879	0.438	0.909	1.643	3,328	3,328	3,299
Israel	0.255	0.675	3.612	0.622	1.264	3.532	22,101	22,101	20,099
Japan	0.155	0.332	6.196	0.305	0.979	2.671	305,915	299,294	269,731
Netherlands	0.143	0.330	6.716	0.304	0.665	2.719	642,784	642,133	583,657
Norway	0.188	0.953	5.905	0.550	1.376	2.449	9,853	9,853	9,173
Sweden	0.119	0.817	4.341	0.552	4.590	2.929	20,625	20,625	18,366
Switzerland	0.147	0.429	6.622	0.336	0.764	2.638	276,189	273,708	251,915
United Kingdom	0.165	0.376	5.828	0.350	0.644	2.727	493,059	481,225	434,034
Total	0.161	0.409	6.101	0.370	1.059	2.942	2,376,554	2,342,231	2,108,749

This table reports the summary statistics of return and liquidity characteristics for U.S. firms cross-listed abroad. The sample period is 1950-2013. Only the markets of the first U.S. firm cross-listings are considered. All the stock returns and liquidity measures are computed from CRSP daily stock dataset. Return is the annualized daily holding period return including dividends. Turnover is the percentage of the daily trading volume out of the total shares outstanding. Liq is the Amihud (2002) liquidity measure based on price impact and is computed as $-\log((10^6 \times |r_t|)/(PRC_t \times Vol_t))$, where PRC_t is the closing price of the stock, $|r_t|$ is the absolute value of stock return, and Vol_t is the trading volume at time t. All variables are winsorized at 1% and 99%.

Table 3: Comparison of U.S. firms' liquidity before and after cross-listing

	Full sample				Sub-samples	
	(1)	(2)	(3)	(4)	1950-1981	1982-2013
$R_{i,t\text{-}1}$	0.166***	0.167***	0.146***	0.147***	0.0935***	0.174***
	(26.91)	(8.32)	(7.72)	(7.68)	(10.36)	(9.61)
$R_{US,t\text{-}1}$	0.142***	0.348***	0.245***	0.248***	0.203***	0.221***
	(7.88)	(5.07)	(4.06)	(4.04)	(5.52)	(3.69)
$R_{IN,t\text{-}1}$	0.130	0.122	0.079	0.124	0.468*	0.049
	(0.97)	(0.33)	(0.23)	(0.37)	(1.87)	(0.13)
$CL_{i,t} \times R_{US,t\text{-}1}$		-0.264***	-0.240***	-0.239***	-0.162***	-0.202***
		(-4.02)	(-3.90)	(-3.89)	(-4.00)	(-3.42)
$CL_{i,t} \times R_{IN,t\text{-}1}$		0.068	0.022	0.024	-0.011	0.021
		(0.20)	(0.69)	(0.76)	(-0.72)	(0.51)
$CL_{i,t}$		0.163	-0.130	-0.091	-0.131	0.094
		(0.13)	(-0.12)	(-0.09)	(-0.81)	(0.08)
$\Delta\sigma_{i,t\text{-}1}$			-0.099***	-0.129***	-0.098***	-0.152***
			(-6.42)	(-6.50)	(-7.65)	(-3.44)
$\Delta STOV_{i,t\text{-}1}$			0.019***	0.019***	0.008***	0.025***
			(7.56)	(7.34)	(3.09)	(5.31)
$\Delta\sigma_{US,t\text{-}1}$				0.083***	0.048***	0.012***
				(3.22)	(4.07)	(2.86)
$\Delta STOV_{US,t\text{-}1}$				0.005	0.020***	-0.001
				(0.55)	(4.72)	(-0.15)
$\Delta\sigma_{IN,t\text{-}1}$				0.014**	0.005	0.018
				(2.04)	(1.24)	(1.72)
$\Delta STOV_{IN,t\text{-}1}$				-0.052	-0.038	-0.048
				(-0.50)	(-0.55)	(-0.32)
Intercept	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Cluster (Country)	Yes	Yes	Yes	Yes	Yes	Yes
Obs.	91,928	91,921	91,921	91,920	49,731	42,189
Adj. R^2	0.015	0.015	0.222	0.223	0.349	0.209
$R_{US,t\text{-}1} + CL_{i,t} \times R_{US,t\text{-}1} = 0$		0.084***	0.005	0.009	0.041***	0.019
p-value		[0.00]	[0.74]	[0.61]	[0.00]	[0.61]

Table 3 (continued)

This table shows the results from panel regression of the U.S. cross-listed firms' liquidity innovation on the lagged firm stock return and the U.S. and international market return variables. The sample period is 1950-2013. It reports aggregate tests (columns 1-4) and estimations over two equal 32-year sub-periods (columns 5-6). The U.S. stock market information is from CRSP, and international stock markets data is from DataStream. The dependent variable, $\Delta Liq_{i,t}$, is the change in monthly Amihud liquidity measure for each individual firm i at time t. First, for each individual stock, we calculate the monthly average Amihud liquidity measure from its daily measure. Then we compute the liquidity innovation as percentage change in the monthly Amihud liquidity measure, i.e. $(Liq_{i,t} - Liq_{i,t})/Liq_{i,t-1}$. The variables $R_{i,t-1}$, $R_{US,t-1}$, and $R_{IN,t-1}$ are the lagged monthly returns for firm i, CRSP total market index, and international markets, respectively. For each firm i, $R_{IN,t-1}$ is constructed as the equally-weighted average of MSCI country index return for all hosting markets for its cross-listings at time t. $CL_{i,t}$ is a dummy equal to one after the initial cross-listing date by firm i and to zero for the time before the listing. The control variables include the lagged changes in in firm volatility, $\sigma_{i,t-1}$, its individual shares turnover, $\Delta STOV_{i,t-1}$, the U.S. market volatility, $\Delta\sigma_{US,t-1}$, the aggregate U.S. market turnover, $\Delta STOV_{US,t-1}$, as well as international market volatility, $\Delta\sigma_{IN,t-1}$, and international market turnover, $\Delta STOV_{IN,t-1}$. The U.S. market volatility is the monthly standard deviation of CRSP total market index return. The international market volatility is the standard deviation of monthly foreign market returns. The aggregate U.S. market turnover is the equally-weighted share turnover of all firms listed in NYSE and NASDAQ. For each firm i, the aggregate international market turnover is the equally-weighted share turnover of all firms with the same hosting market as firm i. The last row of Panel A shows the F-test whether $R_{US,t-1} + \text{CL} \times R_{US,t-1}$ is different from zero with the corresponding p-value. The intercept and firm fixed effects are present in each regression, but their estimates are not shown. The standard errors are clustered by the host country. The table also reports the number of observations and the adjusted R-squared. ***, **, and * indicate significance at 1%, 5%, and 10% levels, respectively.

Table 4: Analysis of U.S. cross-listed firms' liquidity under different U.S. and foreign market characteristics

Panel A: U.S. market characteristics

	U.S. market return				U.S. market volatility	
	Below 50%	Above 50%	Below 25%	Above 75%	Below 50%	Above 50%
$R_{i,t\text{-}1}$	0.171***	0.132***	0.199***	0.122***	0.154***	0.137***
	(6.69)	(8.25)	(5.70)	(6.46)	(7.23)	(6.59)
$R_{US,t\text{-}1}$	0.337***	0.164***	0.332***	0.159**	0.147*	0.293***
	(4.51)	(3.37)	(3.61)	(2.30)	(1.67)	(2.73)
$R_{IN,t\text{-}1}$	0.349	-0.111	-0.010	-0.281	0.375	-0.273
	(0.49)	(-0.28)	(-0.01)	(-0.54)	(0.77)	(-0.40)
$CL_{i,t} \times R_{US,t\text{-}1}$	-0.300***	-0.188***	-0.311***	-0.186**	-0.179**	-0.271***
	(-4.20)	(-2.81)	(-3.01)	(-2.01)	(-2.33)	(-2.71)
$CL_{i,t} \times R_{IN,t\text{-}1}$	-0.028	0.517	0.510	0.105**	0.307	0.461
	(-0.04)	(1.20)	(0.47)	(2.01)	(0.08)	(0.67)
$CL_{i,t}$	0.498	-0.544	0.780	0.0703	-0.312	0.257
	(0.92)	(-1.10)	(1.33)	(0.08)	(-1.11)	(0.83)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Intercept	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Cluster (Country)	Yes	Yes	Yes	Yes	Yes	Yes
Obs.	45,567	46,353	22,504	22,725	45,863	46,058
Adj. R^2	0.232	0.211	0.215	0.232	0.230	0.212

Panel B: Foreign market characteristics

	Number of foreign markets		Market liquidity		Market capitalization	
	Single	Multiple	Low	High	Low	High
$R_{i,t\text{-}1}$	0.173***	0.086***	0.190***	0.110***	0.163***	0.080***
	(8.73)	(10.63)	(11.63)	(10.00)	(7.78)	(21.70)
$R_{US,t\text{-}1}$	0.227***	0.294***	0.208***	0.302***	0.227***	0.340***
	(2.84)	(8.94)	(5.07)	(3.56)	(3.26)	(6.18)
$R_{IN,t\text{-}1}$	0.660	0.127	-0.131	0.198	0.990	-0.027
	(0.17)	(0.43)	(-0.21)	(0.60)	(0.27)	(-0.01)
$CL_{i,t} \times R_{US,t\text{-}1}$	-0.161*	-0.260***	-0.183*	-0.272***	-0.187**	-0.313***
	(-1.70)	(-8.45)	(-1.79)	(-3.65)	(-2.45)	(-5.92)
$CL_{i,t} \times R_{IN,t\text{-}1}$	0.394	-0.009	0.806	-0.077	0.319	0.113
	(0.90)	(-0.03)	(1.48)	(-0.24)	(0.88)	(0.41)
$CL_{i,t}$	-0.298	-0.340	-0.152	0.747	-0.221	-0.097
	(-0.18)	(-0.60)	(-0.82)	(0.54)	(-0.16)	(-0.16)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Intercept	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Cluster (Country)	Yes	Yes	Yes	Yes	Yes	Yes
Obs.	46,447	45,473	30,382	61,538	60,193	31,728
Adj. R^2	0.214	0.534	0.235	0.226	0.217	0.533

Table 4 (continued)

This table shows the results from panel regression of the U.S. cross-listed firms' liquidity innovation on the lagged firm stock return and the U.S. and international market return variables for different market-level characteristics. The sample period is 1950-2013. Panel A shows the results for different U.S. market return and volatility conditions. Panel B reports the results for three characteristics of foreign markets: the number of host markets with trading of a given U.S. firm, host market liquidity, and host market capitalization. The U.S. stock market information is from CRSP, and international stock markets data is from DataStream. The dependent variable, $\Delta Liq_{i,t}$, is the change in monthly Amihud liquidity measure for each individual firm *i* at time *t*. The variables $R_{i,t\text{-}1}$, $R_{US,t\text{-}1}$ and $R_{IN,t\text{-}1}$ are the lagged monthly returns for firm *i*, the S&P500 index, and the international market returns, respectively. For each firm *i*, $R_{IN,t\text{-}1}$ is constructed as the equally-weighted average of MSCI country index return for all hosting markets for its cross-listings at time *t*. $CL_{i,t}$ is a dummy equal to one after the initial cross-listing date of firm *i* and to zero for the time before the listing. The control variables are the same as in Table 3. The market liquidity is the zero-return measure of Lesmond, Ogden, and Trzcinka (1999). It is the equally-weighted average proportion of zero daily returns across all firms in a given country from 1977 to 2010 and is taken from Goyenko and Sarkissian (2014). The host market capitalization information is from the World Development Indicators (WDI) database at the World Bank. The control variables, intercept and firm fixed effects are present in each regression, but their estimates are not shown. The standard errors are clustered by the host country. The table also reports the number of observations and the adjusted R-squared. ***, **, and * indicate significance at 1%, 5%, and 10% levels, respectively.

Table 5: Analysis of U.S. cross-listed firms' liquidity across various firm characteristics

	Stock PIN		Stock volatility		Foreign income	
	Low	High	Low	High	Low	High
$R_{i,t\text{-}1}$	0.0753***	0.178***	0.075***	0.159***	0.127***	0.172***
	(14.81)	(10.78)	(29.29)	(8.14)	(6.48)	(7.58)
$R_{US,t\text{-}1}$	0.125***	0.328***	0.210***	0.303***	0.221***	0.313***
	(4.64)	(3.64)	(4.29)	(3.27)	(3.56)	(2.82)
$R_{IN,t\text{-}1}$	-0.076	0.232	0.323**	-0.209	-0.116	0.562
	(-0.43)	(0.45)	(2.64)	(-0.40)	(-0.27)	(1.14)
$CL_{i,t} \times R_{US,t\text{-}1}$	-0.109***	-0.272***	-0.178***	-0.280***	-0.196***	-0.319***
	(-3.82)	(-2.68)	(-3.75)	(-2.69)	(-3.56)	(-2.86)
$CL_{i,t} \times R_{IN,t\text{-}1}$	0.094	0.384	-0.174**	0.745	0.388	-0.102
	(0.50)	(0.67)	(-2.44)	(1.43)	(1.02)	(-0.17)
$CL_{i,t}$	0.151***	0.048	-0.075	0.004	-0.291	0.386
	(3.33)	(0.24)	(-1.72)	(0.02)	(-1.59)	(1.72)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Intercept	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Cluster (Country)	Yes	Yes	Yes	Yes	Yes	Yes
Obs.	45,895	46,026	46,215	45,706	50,312	41,609
Adj. R^2	0.507	0.220	0.409	0.217	0.244	0.205

This table shows the results from panel regression of the U.S. cross-listed firms' liquidity innovation on the lagged firm stock return and the U.S. and international market return variables for different firm-level characteristics. The sample period is 1950-2013. The U.S. stock market information is from CRSP, and international stock markets data is from DataStream. The dependent variable, $\Delta Liq_{i,t}$, is the change in monthly Amihud liquidity measure for each individual firm i at time t. The variables $R_{i,t\text{-}1}$, $R_{US,t\text{-}1}$ and $R_{IN,t\text{-}1}$ are the lagged monthly returns for firm i, the S&P500 index, and the international market returns, respectively. For each firm i, $R_{IN,t\text{-}1}$ is constructed as the equally-weighted average of MSCI country index return for all hosting markets for its cross-listings at time t. $CL_{i,t}$ is a dummy equal to one after the initial cross-listing date of firm i and to zero for the time before the listing. The control variables are the same as in Table 3. The firm characteristics are: the probability of informed trading (PIN), total volatility, and the proportion of foreign income. All firm specific information is collected at the end of each year and averaged over the sample period. The PINs are calculated using the methodology of Venter and Jongh (2006). Firm volatility is the standard deviation of firm gross returns over the sample period. Foreign income is the proportion of the firm's foreign pretax income out of the total pretax income. All firm characteristic samples are split at the median. The control variables, intercept, and firm fixed effects are present in each regression, but their estimates are not shown. The standard errors are clustered by the host country. The table also reports the number of observations and the adjusted R-squared. ***, **, and * indicate significance at 1%, 5%, and 10% levels, respectively.

Table 6: Summary statistics of characteristic of U.S. firms with and without cross-listings

	Variable	Obs.	Mean	S.D.	Min	Max
Cross-listed firms	Book-to-market ratio	281	0.701	1.385	0.003	18.140
	Leverage ratio	281	0.397	0.203	0.001	0.967
	Market capitalization (ln)	281	8.366	2.355	1.695	12.740
All firms ex cross-listings	Book-to-market ratio	8,548	0.717	1.355	0.000	58.051
	Leverage ratio	8,548	0.477	0.250	0.000	1.000
	Market capitalization (ln)	8,548	5.095	2.091	-1.761	12.288
Matched sample of firms	Book-to-market ratio	545	0.713	2.495	0.004	48.151
	Leverage ratio	545	0.446	0.217	0.004	0.993
	Market capitalization (ln)	545	6.978	2.233	-0.441	12.063

This table reports the summary statistics of firm characteristics for U.S. firms with cross-listings, U.S. firms without cross-listings, and the matched sample of non-cross-listed firms. The sample period is 1950-2013. Accounting information is from Compustat and the stock market information is from CRSP. All reported firm characteristics are collected at the end of each year and averaged over the sample period. Book-to-market ratio is computed as firm's book value of equity divided by the market value of equity. Leverage ratio is the long-term debt divided by the sum of long-term debt and market value of equity. Market capitalization is the logarithm of firms' total dollar market value of all outstanding common shares. S.D. is the standard deviation. The sample of cross-listed firms includes only those cross-listed U.S. firms that have valid links between CRSP and Compustat fundamental and supplemental data. The samples of all firms excluding cross-listings are the U.S. firms without foreign listings, but with the same four-digit SIC code as cross-listed firms. The matched sample is constructed using the propensity score matching technique as follows. Using logistic regressions, we compute the propensity score for all non-cross-listed firms with the same four-digit SIC code as cross-listed firms. The cofounders in the logistic regressions include book-to-market ratio, leverage ratio, and market capitalization. Then, for each U.S. firm with a cross-listing, we select two control firms with the closest propensity score to the cross-listed firm. We allow the control firms to appear multiple times during the matching process.

Table 7: Analysis of U.S. cross-listed firms' liquidity for cross-listed and matched non-cross-listed samples

	Cross-listed firms			Matched sample of firms		
		Period to cross-listing			Period to cross-listing	
	Full sample	Before	After	Full sample	Before	After
$R_{i,t\text{-}1}$	0.202***	0.258***	0.183***	0.146***	0.163***	0.133***
	(15.16)	(8.21)	(12.57)	(13.46)	(8.50)	(10.45)
$R_{US,t\text{-}1}$	0.169***	0.285***	0.133***	0.269***	0.265***	0.274***
	(6.72)	(4.45)	(4.77)	(7.65)	(4.02)	(6.33)
$R_{IN,t\text{-}1}$	0.011	0.019	0.015	-0.041	-0.045	-0.040
	(0.83)	(0.58)	(1.15)	(-1.59)	(-1.14)	(-1.12)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Intercept	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Cluster (Firm)	Yes	Yes	Yes	Yes	Yes	Yes
Obs.	91,921	18,986	72,935	105,470	31,492	73,978
Adj. R^2	0.154	0.194	0.144	0.224	0.244	0.214
$R_{US,After} = R_{US,Before}$			-0.152***			0.009
p-value			[0.01]			[0.89]
$R_{US,CL} = R_{US,MS}$	-0.100***	0.020	-0.141***			
p-value	[0.00]	[0.75]	[0.00]			

This table shows the results from panel regression of the U.S. cross-listed firms' liquidity innovation on the lagged firm stock return and the U.S. and international market return variables for the cross-listed and matched samples of firms. The sample period is 1950-2013. The U.S. stock market information is from CRSP; and international stock markets data are from DataStream. Each firm in a matched sample is selected based on the procedure described in Table 6. The dependent variable, $\Delta Liq_{i,t}$, is the change in monthly Amihud liquidity measure for each individual firm i at time t. The variables $R_{i,t\text{-}1}$, $R_{US,t\text{-}1}$, and $R_{IN,t\text{-}1}$ are the lagged monthly returns for firm i, CRSP total market index, and international markets, respectively. For each firm i, $R_{IN,t\text{-}1}$ is constructed as the equally-weighted average of MSCI country index return for all hosting markets for its cross-listings at time t. For each firm in the matched sample, $R_{IN,t\text{-}1}$ is set to be identical to the corresponding cross-listed firm. The control variables are the same as in Table 3. The last two rows of the table report two Chi-squared tests with the corresponding p-values. The first tests whether the coefficients on $R_{US,t\text{-}1}$ are statistically different after and before the initial foreign listing date ($R_{US,After} = R_{US,Before}$). The second tests whether the coefficients on $R_{US,t\text{-}1}$ are statistically different between cross-listed firms and firms from the matched sample ($R_{US,CL} = R_{US,MS}$). The control variables, intercept, and firm fixed effects are present in each regression, but their estimates are not shown. The standard errors are clustered by firm. The table also reports the number of observations and the adjusted R-squared. ***, **, and * indicate significance at 1%, 5%, and 10% levels, respectively.

Table 8: Liquidity provision strategy

Panel A: Aggregate samples

	Before cross-listing			After cross-listing				
Portfolio return (%)	μ	σ	ρ	μ	σ	ρ	$\mu_{Before} - \mu_{After}$	t-stat
Matched firms	1.219	5.185	-0.068	1.116	3.740	-0.082	0.103**	2.02
Cross-listed firms	0.745	5.613	-0.045	0.479	3.425	-0.061	0.266***	5.11

Panel B: Cross-listed firm sample

	Before cross-listing			After cross-listing				
Portfolio return (%)	μ	σ	ρ	μ	σ	ρ	$\mu_{Before} - \mu_{After}$	t-stat
Number of foreign listing markets								
Low (single)	0.789	5.886	-0.046	0.680	4.213	0.006	0.108*	1.89
High (multiple)	0.534	3.933	-0.009	0.257	2.712	0.002	0.277***	7.31
Foreign market liquidity								
Low	0.799	6.714	-0.069	0.664	4.492	0.019	0.135**	2.11
High	0.577	6.047	-0.007	0.366	2.938	-0.026	0.211***	3.96
Foreign market capitalization								
Low	0.881	6.627	-0.047	0.681	4.279	-0.027	0.200***	3.19
High	0.538	4.823	-0.036	0.256	3.469	0.113	0.282***	5.99
Firm PIN								
Low	0.312	4.365	-0.062	0.243	2.627	-0.001	0.070*	1.72
High	0.930	6.820	-0.005	0.785	4.692	-0.026	0.145**	2.21
Firm volatility								
Low	0.231	2.954	-0.049	0.235	1.765	-0.032	-0.004	-0.13
High	0.918	6.826	-0.039	0.797	4.843	-0.006	0.120*	1.81
Firm foreign income								
Low	0.612	7.457	-0.031	0.562	4.026	-0.018	0.050	0.74
High	0.701	5.754	-0.071	0.423	3.193	-0.017	0.278***	5.33

Table 8 (continued)

This table reports the weekly portfolio return from the liquidity provision strategy as in Lehman (1990), Lo and MacKinlay (1990), and Nagel (2012). The sample period is from 1950 to 2013. The accounting information is from Compustat and stock market information is from CRSP. The liquidity provision trading strategy specifies the portfolio weight for stock i at time t as

$$w_{i,t} = -\left(1/2\sum_{i}^{N}|R_{i,t-s} - R_{m,t-s}|\right)^{-1}(R_{i,t-s} - R_{m,t-s}),$$

where $R_{m,t-s}$ is the s-period lagged daily equally-weighted market index return, $R_{i,t-s}$ is the s-period lagged daily gross return of firm i, and N is the total number of stocks in the portfolio. The portfolio return at time t for the liquidity provision trading strategy is calculated as

$$\Pi_{s,t} = -\left(1/2\sum_{i}^{N}|R_{i,t-s} - R_{m,t-s}|\right)^{-1}\sum_{i=1}^{N}(R_{i,t-s} - R_{m,t-s})R_{i,t}.$$

The weekly portfolio return is computed for s = 1, 2…, 5 over the sample period as

$$\Pi_t = \sum_{s=1}^{5}\Pi_{s,t}.$$

The mean, μ, standard deviation, σ, and autocorrelation, ρ, of aggregated portfolio returns, Π_t, are reported in each column. The Panel A shows the portfolio returns for cross-listed firms versus the matched sample. The details of the cross-listed and the matched sample firms are in Table 6. Panel B shows portfolio returns categorized by three foreign market characteristics (the number of markets for firm listings, market liquidity, and market capitalization) and three firm-specific characteristics (probability of informed trading, PIN, total volatility, and foreign income). All these variables are described in Tables 4 and 5. The first two rows of each panel reports the portfolio return of sub-samples based on the median-split. The third row of each panel computes the difference between the means. The last row of each panel reports the results of the two-sample t-test. ***, **, and * indicate significance at 1%, 5%, and 10% levels, respectively.

Table 9: Summary statistics of liquidity betas

	Cross-listed firms			S&P 500 firms without cross-listing			
	Mean	S.D.	Obs.	Mean	S.D.	Obs.	Difference
$\beta(Liq_i, Liq_m)$	0.891	2.06	283	1.298	2.31	1,578	0.407*** (3.01)
$\beta(Liq_i, r_m)$	0.341	0.99	282	0.542	1.27	1,575	0.201*** (2.99)
$\beta(r_i, Liq_m)$	0.145	0.66	280	0.149	0.75	1,572	0.004 (0.09)

This table reports the means, standard deviations and the number of observations of the estimated liquidity betas for cross-listed U.S. firms and S&P 500 firms without foreign listings. The sample period is 1950-2013. The sample of cross-listed U.S. firms includes the U.S. firms with foreign listings after their initial foreign listing date. The sample of S&P 500 excluding cross-listings consists of the S&P 500 constituents without foreign listings. This sample is reconstructed after each change in the constituents of the S&P 500 index. To be included in our sample, we also require the firms to have at least twelve months of return and liquidity history available. The stock market return, risk free rate, and liquidity information is computed from CRSP. For each firm *i*, we fit the following bivariate model to obtain the three liquidity betas:

$$y_t = \alpha_i + \beta_i x_t + \varepsilon_t\,,\ \varepsilon_t \sim N(0, \sigma_i^2)\,,$$

where (y_i, x_i) can take the forms of (Liq_i, Liq_m), (Liq_i, r_m), and (r_i, Liq_m). Liq_i is the innovation of firm *i*'s monthly Amihud liquidity measure, obtained from the estimated residuals in the univariate AR(2) model. Liq_m is the innovation of monthly market aggregated Amihud liquidity measure obtained from the estimated residuals in the univariate AR(2) model. The market aggregated Amihud liquidity measure is the equally-weighted Amihud liquidity measure of all firms listed on the NYSE and NASDAQ. r_i and r_m are the monthly excess returns of firm *i* and CRSP U.S. total market index over the one-month Treasury bill rate, respectively. The two sample *t*-test of the difference in the means is reported in the last column with the corresponding t-statistics in parentheses. *** indicates significance at the 1% level.

Table 10: Bayesian estimation of liquidity betas

		Mean	Median	Highest Density Interval (HDI)	
				Lower bound	Upper bound
$\beta(Liq_i, Liq_m)$	μ_1	0.673	0.673	0.614	0.725
	μ_2	0.791	0.790	0.757	0.826
	$\mu_1 - \mu_2$	-0.118	-0.118	-0.052	-0.183
	σ_1	0.315	0.315	0.268	0.367
	σ_2	0.473	0.472	0.434	0.515
	$\sigma_1 - \sigma_2$	-0.157	-0.158	-0.097	-0.220
$\beta(Liq_i, r_m)$	μ_1	0.251	0.251	0.229	0.273
	μ_2	0.289	0.289	0.271	0.307
	$\mu_1 - \mu_2$	-0.037	-0.037	-0.008	-0.064
	σ_1	0.127	0.127	0.106	0.147
	σ_2	0.240	0.240	0.221	0.260
	$\sigma_1 - \sigma_2$	-0.113	-0.113	-0.086	-0.141
$\beta(r_i, Liq_m)$	μ_1	0.173	0.173	0.159	0.186
	μ_2	0.172	0.172	0.167	0.177
	$\mu_1 - \mu_2$	0.001	0.003	-0.076	0.066
	σ_1	0.471	0.470	0.410	0.530
	σ_2	0.402	0.402	0.378	0.429
	$\sigma_1 - \sigma_2$	0.068	0.067	0.010	0.130

This table reports the results of the Bayesian two-sample *t*-tests based on the liquidity betas of cross-listed U.S. firms (sample 1) and the S&P 500 index firms without foreign listings (sample 2). The estimation of the three liquidity betas is outlined in Table 9. The liquidity betas are assumed to be independent and identically distributed (i.i.d.) draws from a *t*-distribution with different means, μ_1 and μ_2, and standard deviations, σ_1 and σ_2, for each population, and with a common normality parameter, ν. The priors of these parameters are assumed to be minimally informative: normal priors with large standard deviation for μ_k, broad uniform priors for σ_k, and a shifted-exponential prior for ν, where $k = 1, 2$. Given the observed liquidity betas β_i for each firm *i*, the Bayesian inference then reallocates credibility of the combination of values $\{\mu_1, \mu_2, \sigma_1, \sigma_2, \nu\}$ in the model as $\Pr(\mu_1, \mu_2, \sigma_1, \sigma_2, \nu \mid \beta_j)$. The posterior distribution of $\{\mu_1, \mu_2, \sigma_1, \sigma_2, \nu\}$ is approximated by generating a large representative sample through Markov Chain Monte Carlo (MCMC) methods and Gibbs sampling algorithm. The reported statistics of the MCMC samples for the Bayesian posterior distributions of $\{\mu_1, \mu_2, \sigma_1, \sigma_2, \nu\}$ include the differences between the sample means, $\mu_1 - \mu_2$, and standard deviations, $\sigma_1 - \sigma_2$. The full estimation details are in Casella and George (1992), Gonen et al. (2005), and Kruschke (2012). HDI denotes the 95% Highest Density Interval, also known as the Bayesian confidence interval.

Table 11: Estimated parameters of the regime-switching model with time varying transition probabilities

	Cross-listed firms			S&P 500 firms without cross-listings		
y_t, x_t	Liq_i, Liq_m	Liq_i, r_m	r_i, Liq_m	Liq_i, Liq_m	Liq_i, r_m	r_i, Liq_m
α_1	-0.002	-0.004	0.008	-0.006*	-0.007***	0.023***
	(-0.01)	(-1.24)	(1.60)	(-1.83)	(-5.58)	(5.15)
α_2	-0.001	-0.005**	0.014***	-0.001	-0.009**	0.006**
	(-0.01)	(-2.45)	(10.85)	(-0.52)	(-2.26)	(2.32)
σ_1	0.180***	0.377***	0.868***	0.174***	0.532***	1.801***
	(12.86)	(9.67)	(3.14)	(15.43)	(12.33)	(11.25)
σ_2	0.588***	0.513***	1.765***	1.112***	2.475***	1.051***
	(7.94)	(10.71)	(7.33)	(10.11)	(9.67)	(7.50)
β_1	0.056***	0.165***	0.074***	0.133***	0.384***	0.063***
	(3.74)	(8.61)	(5.38)	(5.31)	(16.93)	(6.51)
β_2	0.279***	0.413***	0.452***	0.604***	0.661***	0.505***
	(3.54)	(10.19)	(16.61)	(6.97)	(11.85)	(17.42)
d_1	-0.327***	-0.422**	-0.256***	-0.687***	-0.087*	-0.267**
	(-5.03)	(-2.62)	(-3.01)	(-4.16)	(-1.69)	(2.51)
d_2	1.118**	0.293***	0.285*	0.249***	0.192**	0.269**
	(2.84)	(3.22)	(1.77)	(2.66)	(2.15)	(2.07)
LR Tests:						
$\alpha_1 = \alpha_2$	0.04	18.37***	0.98	0.23	0.56	4.45**
p-value	[0.84]	[0.00]	[0.16]	[0.63]	[0.45]	[0.03]
$\sigma_1 = \sigma_2$	9.56***	19.88***	7.11***	16.49***	12.65***	0.96
p-value	[0.00]	[0.00]	[0.01]	[0.00]	[0.00]	[0.33]
$\beta_1 = \beta_2$	20.18***	2.16	7.96***	39.39***	17.68***	65.92***
p-value	[0.00]	[0.14]	[0.01]	[0.00]	[0.00]	[0.00]
$\beta_{1,CL} - \beta_{2,CL} = \beta_{1,SP} - \beta_{2,SP}$	16.61***	13.46***	1.88			
p-value	[0.00]	[0.01]	[0.24]			

Table 11 (continued)

This table shows the estimation of time-varying liquidity betas of cross-listed U.S. firms and S&P 500 firms without foreign listings. The liquidity betas are estimated from a regime switching model with time varying transition probabilities. The sample period is 1950-2013. The stock market returns, shares turnovers, liquidity information and risk free rates are computed from CRSP. The regime switching model is described as follows:

$$y_t = \alpha_{s_t} + \beta_{s_t} x_t + \varepsilon_t \, , \; \varepsilon_t \sim N(0, \sigma^2_{s_t}) \, ,$$

$$\Pr(s_t = s \mid s_{t-1} = s, STOV_{t-1}) = \Phi(c_{s_t} + d_{s_t} \cdot STOV_{t-1}) \, ,$$

where s_t =1, 2 is the state at time *t*. α_{s_t} β_{s_t} $\sigma^2_{s_t}$ are the intercept, liquidity betas, and variance of the innovation at state s_t, respectively. $STOV_{t-1}$ is the lag of de-trended aggregate share turnover. $\Phi(\cdot)$ is the cumulative density function of standard normal distributions. Each pair (y_i, x_i) can take the form of (Liq_i, Liq_m), (Liq_i, r_m), or (r_i, Liq_m). The estimation of the three liquidity betas is outlined in Table 9. The table also shows chi-square statistics and *p*-values (in square brackets) for the likelihood ratio tests (LR Tests) on various parameter restrictions. The first three rows test whether the parameters are time-varying. The last row of the table tests the null hypothesis that the difference in liquidity betas between the two states is statistically identical for cross-listed U.S. firms, $\beta_{i,CL}$, and for the S&P 500 firms without foreign listings, $\beta_{i,SP}$, where *i* =1, 2. ***, **, and * indicate significance at 1%, 5%, and 10% levels, respectively.

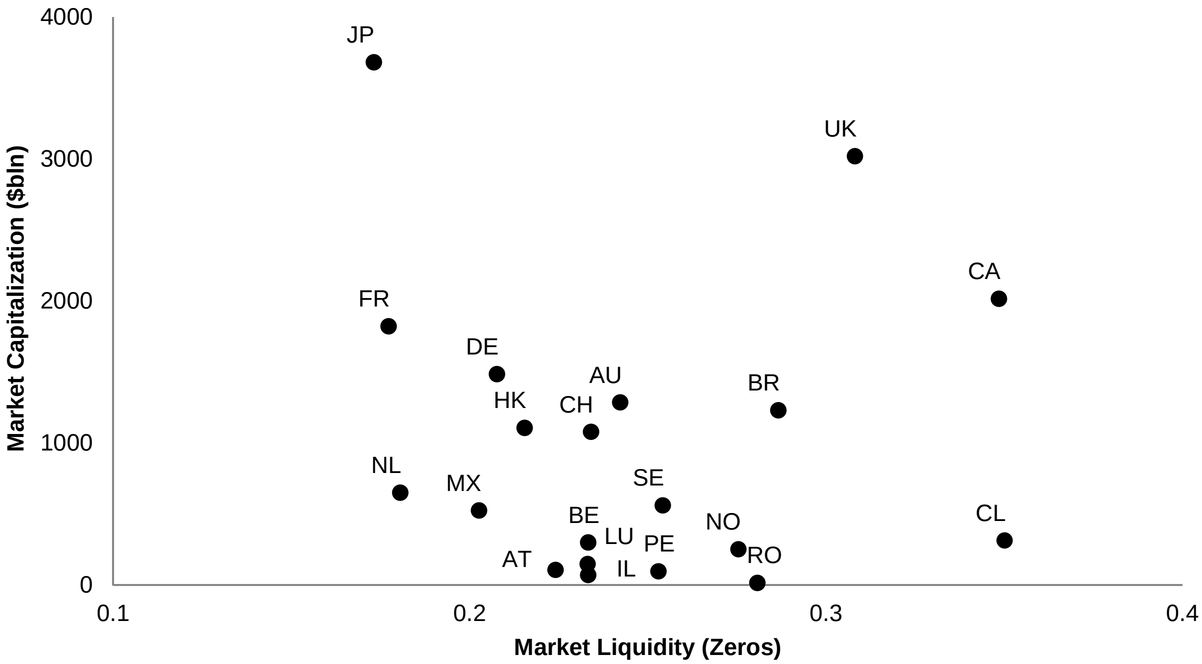
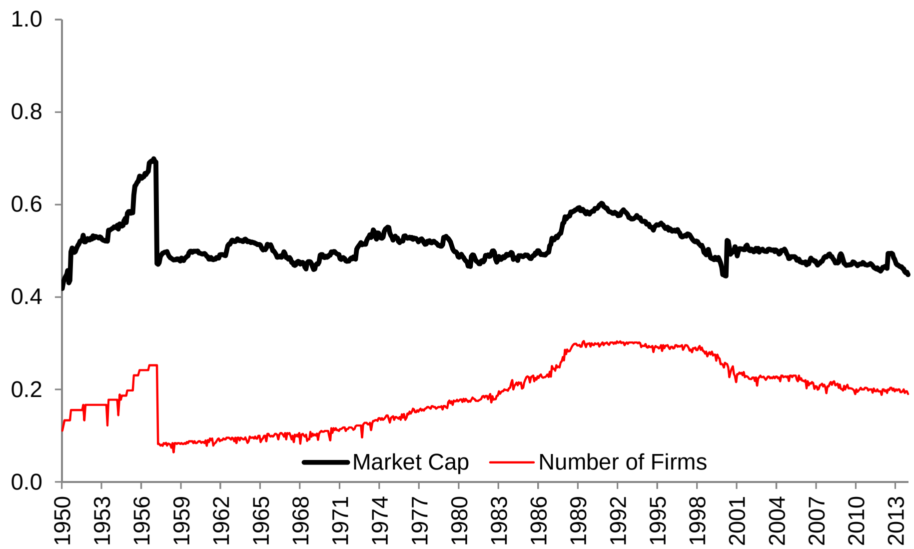
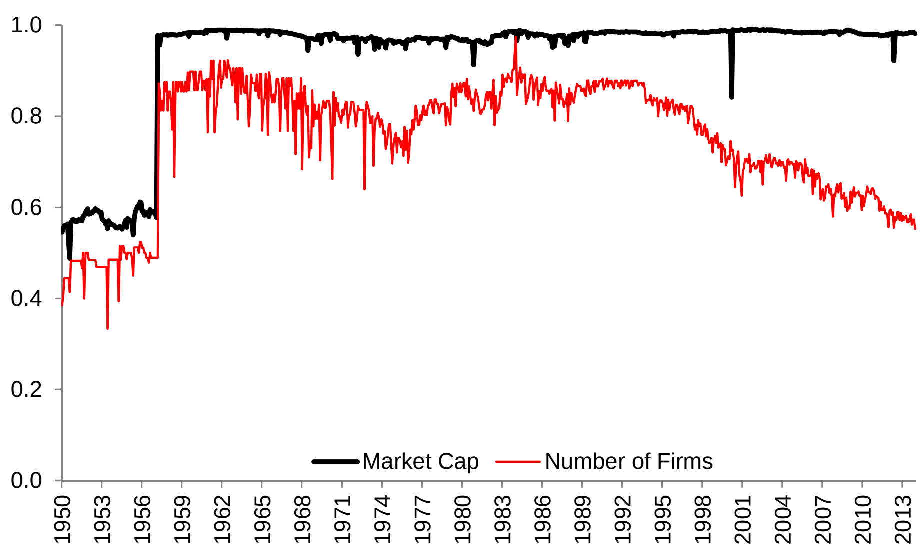


Figure 1: Market liquidity and market capitalization. This figure shows the average market liquidity versus the average market capitalization for 20 countries. The market capitalization (in billion USD) is retrieved from World Bank database. The market liquidity is the zero-return measure (Zeros) proposed by Lesmond, Ogden, and Trzcinka (1999). It is the equally-weighted average proportion of zero daily returns across all firms in a given country from 1950 to 2010 from Goyenko and Sarkissian (2014). The countries are denoted by their respective two-letter codes.



Plot A: Proportion of cross-listed firms in the S&P 500 index



Plot B: Proportion of cross-listed firms from the S&P 500 index relative to all cross-listed firms

Figure 2: Proportion of cross-listed stocks in the S&P 500 index. This figure shows the proportion of cross-listed stocks included in the S&P 500 index from 1950 to 2013 based on market capitalization and the number of listed firms. Plot A reports the proportion of cross-listings out of the S&P 500 index constituents, while Plot B depicts the proportion of cross-listings included in S&P 500 index out of all cross-listings. The market capitalization data and the S&P 500 index constituents' information are from CRSP. The cross-listing data come from several sources: the Sarkissian and Schill public foreign listing database, listing information from the major stock exchanges of each country, and CRSP.