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The Role of Liquidity in ADR Mispricing: Evidence from Latin America

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A B S T R A C T

This paper examines the role of liquidity in explaining mispricing for American Depository Receipt (ADR) issues from four Latin American countries: Argentina, Brazil, Chile, and Mexico. The results developed using panel regression with fixed effects indicate that the severe trading infrequency of some Latin American stocks can significantly influence estimates of liquidity's impact on price deviations. When accounting for trading infrequency and controlling for holding costs and market uncertainty, the results reveal that liquidity of both the ADR and the underlying stock impact ADR mispricing. Furthermore, the evidence suggests the relationship between liquidity and price deviations is not driven by volatile conditions associated with the global financial crisis of 2008. Finally, this paper finds that the impact of liquidity on price deviations is asymmetric with decreases in liquidity exerting a stronger impact on prices than equivalent increases.

Keywords: American Depositary Receipts; Liquidity; Law of one price

Ⅰ. Introduction

American investors seeking to own Latin American equity typically do so through American Depositary Receipts (ADRs). According to the U.S. Treasury International Capital system, 56% of U.S. holdings of Latin American equity in 2007 were in the form of ADRs. This percentage is significantly higher than other regions in the world: For European and Asian equity, only 20% and 14% respectively of U.S. purchases are in the form of ADRs. An important consideration for U.S. investors purchasing ADR issues from Latin America is that Latin American stock markets are smaller and less active than similar developing economies (De la Torre & Schmukler, 2007). As such, they are typically characterized by low liquidity (Lesmond, 2005; Bekaert, Harvey, & Lundblad, 2007).

A 2012 J.P. Morgan publication discussing ADR liquidity suggests that U.S. investors should not worry about ADRs that are illiquid in the U.S. because depositary banks have the ability to tap into liquidity of ADR issuers' home markets. The argument is that ADR liquidity is, in effect, at least equal to the liquidity of its underlying shares. The focus of this paper is on liquidity effects when the *opposite* case is observed; that is, what happens when illiquidity is, on the average, more prevalent for stocks trading in the home market than for their respective ADRs? This is the case in countries like Mexico although issuers of exchange-listed ADRs tend to be the largest and most reputable firms in the home country.

This paper explores whether differences in liquidity explain price differentials arising between ADRs and their

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corresponding stocks trading in Latin American markets. Because ADR investors receive the same cash flows as investors who purchase the underlying stock directly, if the law of one price holds, then the price of the underlying stock should equal the exchange-rate adjusted price of the ADR. Yet, this is not always the case, and price deviations between ADRs and their underlying stocks arise. The existing literature attributes these deviations to different sources including exchange rate expectations, transaction costs, consumer sentiment, holding costs, macroeconomic events, domestic trading volume, and liquidity (Eichler, Karmann, & Malritz, 2009; Kadiyala & Kadiyala, 2004; Grossman, Ozuna, & Simpson, 2007; Gagnon & Karolyi, 2010; Hsu & Wang, 2008; Chan, Jain, & Xia, 2008). Prices must also be adjusted by the conversion ratio. This ratio defines how many shares of the underlying stock are represented by one ADR.

Using panel regression with fixed effects, we document that the severe trading infrequency of some Latin American stocks can significantly influence estimates of liquidity's impact on price deviations. When accounting for trading infrequency, and controlling for holding costs and market uncertainty, our findings reveal that liquidity impacts ADR mispricing. Unlike the findings for developed markets (Chan, Hong and Subrahmanyam, 2008), our results indicate that for ADR issues from Latin America, the liquidity of both ADRs and their corresponding stocks impact price deviations. As the illiquidity of ADRs or home shares rises, share prices fall causing a change in price deviations. Furthermore, our results suggest that the relationship between liquidity and price deviations is not a statistical artifact arising from the liquidity crunch associated with the global financial crisis of 2008. Finally, we document evidence of asymmetric impacts of liquidity on price deviations.

The remainder of this paper is organized as follows: Section II reviews related literature. Section III details the data and methodology. Section IV discusses the empirical results, and Section V concludes.

Ⅱ. Related Literature

Liquidity captures the ease with which an asset can be traded. Therefore, its counterpart, illiquidity, reflects the difficulty or cost of executing a transaction in capital markets. While illiquidity is an elusive concept that is not observed directly, it can arise for several reasons including exogenous transaction costs, inventory risk, and asymmetric information (Amihud, Mendelson, & Pederson, 2005). Due to its multiple components, illiquidity is difficult to quantify since no individual measure captures all its dimensions. Some studies use intraday data to build measures for liquidity: They document an inverse relationship between expected returns and liquidity (Amihud & Mendelson, 1986a, 1986b; Brennan & Subrahmanyam, 1996; Chalmers & Kadlec, 1998). Because intraday data is limited, other studies have developed liquidity measures based on daily price and volume data (Amihud, 2002; Chordia, Huh, & Subrahmanyam, 2009; Datar, Naik, & Radcliffe, 1998; Hasbrouck, 2009; Lesmond, Ogden, & Trzcinka, 1999). While the liquidity measures vary, the findings across these studies are consistent—liquidity is an important factor influencing asset prices. The papers reviewed here represent a small fraction of the literature examining this question. See also Easley & O'Hara (2003) and Amihud et al. (2005) for surveys of the literature.

If liquidity matters for prices, then it can potentially explain price deviations between assets with identical cash flow streams as documented for dual class shares in Norway by Ødegaard (2007) and for closed-end funds by Chan, Jain, and Xia (2008). Of particular importance to this study are the findings of Chan et al. (2008a), which report the impact of liquidity on the price deviations between ADRs and their underlying stocks. They find that higher ADR liquidity is associated with a higher ADR premium but find little support to indicate that changes in the liquidity of the underlying stock affect the ADR premium. An important limitation of this study is that the sample combines ADR issues from developed and emerging markets. Chan et al. (2008b) find that the impact of liquidity on price differentials in closed-end country funds is exacerbated in segmented markets, and according to Hunter (2006), Latin American markets are segmented and exhibit no trend toward greater integration with the U.S. market. In light of these findings, the results in Chan et al. (2008a) may not reflect the true impact of liquidity on price deviations between ADRs and their corresponding Latin American stocks.

Ⅲ. Data and Methodology

A. Measures Employed

The main variable of interest is the price deviation between ADRs and their corresponding stock. Following Gagnon and Karolyi (2010), the quarterly deviation, $Deviation_{i,t}$, is defined as the average of the daily deviations between the ADR and its underlying stock as follows:

$$Deviation_{i,t} = \frac{1}{D_t}\sum_{d=1}^{D_t} l_n\left(\frac{P_{i,d}^{A}}{P_{i,d}^{H}}\right) \quad (1)$$

where $P_{i,d}^{A}$ represents the price of the ADR in dollars; $P_{i,d}^{H}$ represents the price of the underlying stock converted to U.S. dollars at the corresponding daily closing spot exchange rate and adjusted for the ADR conversion ratio (the number of underlying shares equivalent to one ADR); and D_t is the number of trading days in quarter t. Positive (negative) values of $Deviation_{i,t}$ indicate that the ADR trades at a premium (discount) relative to its underlying stock. Chan et al. (2008a) and Grossman et al. (2007) use a variation of this measure to capture ADR mispricing on a monthly basis. In both, the deviation is expressed as the difference between the ADR and the price of the underlying stock relative to the price of the underlying stock with no natural logarithms employed. Their measure and the deviation measured used in the analysis exhibit a correlation coefficient of 0.988 for those firms included in the sample.

Since intraday transaction data is difficult to obtain for emerging markets, the analysis incorporates only liquidity measures that can be computed using daily return and volume data. The first measure, in accordance with Datar et al. (1998) is the turnover rate (ADR Turnover). The quarterly turnover rate is the average of daily turnover rates in each quarter as follows:

$$ADR\ \ Turnover_{i,t} = \frac{1}{D_t}\sum_{d=1}^{D_t}\frac{Vol_{i,d}^{A}}{SO_{i,d}^{A}} \quad (2)$$

where $Vol_{i,d}^{A}$ is the number of ADR shares traded, and $SO_{i,d}^{A}$ is the total ADR shares outstanding on day d in the U.S. market, and D_t is the number of trading days in quarter t. The turnover rate for the ADR's underlying stock (Home Turnover) is calculated in a similar fashion using values from its activity in the respective home market. The turnover rate is easy to calculate and interpret: Since it captures how actively a stock is being traded, higher turnover values correspond to higher liquidity. However, this measure is limited because it does not account for the cost per trade.

The second measure is the Amihud (2002) illiquidity measure calculated as follows:

$$ADR\ \ Illiquidity_{i,t} = \frac{1}{D_t}\sum_{d=1}^{D_t}\frac{|R_{id}^{A}|}{VOL_{i,d}^{A}} \quad (3)$$

where $R_{i,d}^{A}$ is the daily return of the i-th ADR on day d, and $VOL_{i,d}^{A}$ is the dollar trading volume of the i-th ADR on day d defined as the number of shares traded multiplied by the ADR price on day d, scaled by 10^6, and D_t is the number of trading days in quarter t. The Amihud illiquidity measure for the corresponding underlying share (Home Illiquidity) is computed similarly, but the daily trading volume is converted from the home currency into U.S. dollars at the corresponding exchange rate on day d. This adjustment ensures that the measure is calculated on the same basis for all countries.

As defined by Amihud (2002), this measure can "be interpreted as the daily price response associated with one dollar of trading volume" (p.32). Since the measure quantifies the return response to a given trade size, it roughly measures the price impact of order flow. Higher values of this measure indicate greater price responses to changes in volume. Because liquid markets should absorb large trading quantities without a major price response, higher values of this measure indicate lower liquidity. An advantage of this measure is that it is calculated even for days with no price change; however, the measure is undefined on days with no trading volume. While the undefined daily values are not reflected in the quarterly average, lack of trading is indicative of low liquidity. Therefore, in the presence of trading infrequency, the Amihud (2002) measure will not completely capture the illiquidity of the stock in question.

To contend with this problem, the analysis incorporates trading infrequency as an additional measure of illiquidity. In some cases, ADRs and/or their underlying stocks are so illiquid that there is no trading of the stocks for many

regular trading days in any given quarter. Following Chan et al. (2008a), ADR Infrequency is the percentage of U.S. trading days in a given quarter that the ADR is not traded. Chan et al. (2008a) argue that trading infrequency is a problem for ADRs but not their underlying stocks because the underlying stocks of exchange listed ADRs belong to large, actively traded, firms in the home country. However, trading infrequency of the underlying stocks is a problem for this Latin American sample. Therefore, Home Infrequency captures the percentage of trading days, in a given quarter, in the respective home market, that the ADR's underlying stock does not trade.

B. Sample and Descriptive Statistics

Sample construction begins with the set of 121 exchange-listed ADR issues from Argentina, Brazil, Chile and Mexico trading during the 2003-2010 period that are available from the DataStream International database and verifiable via the Bank of New York, Citibank, JP Morgan/Chase or Deutsche Bank's ADR websites. Over-the-counter (OTC) ADR issues are excluded from the sample due to high levels of trading infrequency for most ADRs throughout most of the sample period. My calculations show that trading infrequency for OTC issues is on average 95.23% in Argentina, 71.82% in Brazil, 68.14% in Chile and 63.24% in Mexico. Financial firms (seven from Argentina, four from Brazil, and four from Chile) are excluded because they typically operate in heavily regulated environments. Stocks with missing and/or distorted price or volume data are also excluded. These filters result in 87 ADR programs from Argentina (10), Brazil (38), Chile (11), and Mexico (28). However, upon calculating the price deviation measure, nine firms—Argentina (3), Brazil (2), and Mexico (4)—are excluded due to extreme mispricing. Other firms exhibit extreme mispricing due to a change in the ADR conversion ratio. However, in these nine firms, no change in the conversion ratio is detectable. DataStream International is the source of all data used in calculating price deviations and liquidity measures.

Table 1 displays the descriptive statistics of the sample. As discussed in the previous section, the variables are constructed on a daily basis and averaged by quarter. On average, the price deviations are statistically different from

Table 1. Descriptive Statistics: Price Deviations in Latin America

		Deviation	Turnover		Illiquidity		Infrequency	
			ADR	Home	ADR	Home	ADR	Home
Argentina	Mean	-0.006***	0.002	0.001	0.015	0.011	0.014	0.035
	Std. Dev.	0.017	0.003	0.001	0.059	0.018	0.042	0.067
	t-statistic	-4.839						
Brazil	Mean	0.002***	0.008	0.009	0.004	0.0004	0.021	0.001
	Std. Dev.	0.014	0.018	0.016	0.017	0.002	0.097	0.008
	t-statistic	5.046						
Chile	Mean	0.005***	0.001	0.001	0.004	0.001	0.029	0.018
	Std. Dev.	0.026	0.002	0.001	0.028	0.004	0.064	0.053
	t-statistic	3.49						
Mexico	Mean	-0.009***	0.024	0.008	0.012	0.071	0.038	0.168
	Std. Dev.	0.034	0.099	0.149	0.078	0.325	0.108	0.280
	t-statistic	-6.561						

Notes: Quarterly data from QI 2003 to QIV 2010. Variables are constructed on a daily basis and averaged across quarters. The daily Deviation is the natural logarithm of the ratio of the ADR price to the home share price converted to U.S. dollars at the corresponding closing spot exchange rate and adjusted for the ADR conversion ratio. Daily *ADR Turnover* is calculated as the ratio of volume traded relative to the day's number of shares outstanding. *Home Turnover* is calculated in a similar fashion using values from the respective home market. Daily *ADR Illiquidity* is the ratio of the ADR's return on a given day to the dollar volume traded that day and scaled by 10^6. *Home Illiquidity* is computed similarly, but the daily trading volume is converted from the home currency into U.S. dollars at the corresponding exchange rate. *ADR Infrequency* is the percentage of U.S. trading days in a given quarter that the ADR is *not* traded, and *Home Infrequency* is the percentage of trading days in a given quarter in the respective home market that the ADR's underlying stock does not trade. The t-statistics correspond to tests that the mean of the price deviation measure is equal to zero in each country. The symbol *** indicates statistical significance at the 1% level.

0 albeit small (less than 1% in absolute terms across all countries). In Argentina and Mexico, the price deviation is negative suggesting that on average Argentinean and Mexican ADRs trade at a discount relative to their underlying stocks. The opposite holds in Brazil and Chile where the mean price deviation is positive suggesting that ADRs on average trade at a premium relative to their corresponding stocks.

The average values for the liquidity variables indicate that Latin American markets differ in the level of liquidity of ADRs relative to their underlying stocks. In Brazil and Chile, all measures indicate that illiquidity is equal or higher in the ADR market than the home market. The opposite holds in Mexico where all variables indicate higher illiquidity for the underlying stocks than the ADRs. Particularly striking for Mexico are the values of trading infrequency: on average 3.8% for ADRs but 16.8% for the corresponding stocks trading at home. This means that on average that Mexican ADRs do not trade at all for two days every quarter, but their underlying stocks do not trade for ten days each quarter. For Argentina, the descriptive statistics do not clearly show whether liquidity is higher for ADRs or for their underlying stocks. For example, there is higher turnover and less trading infrequency in the ADR market, but illiquidity, as captured by the Amihud (2002) measure, is on average higher for ADRs than the stocks trading in the domestic market.

C. Methodology

The empirical analysis involves estimating the following equation:

$$Deviation_{i,t} = \alpha + X'_{i,t}\beta + Z'_{i,t}\gamma + u_{i,t} \qquad (4)$$

where $Deviation_{i,t}$ is the price deviation variable from Equation (1); $X'_{i,t}$ is a vector of the aforementioned liquidity measures; $Z'_{i,t}$ is a vector of control variables; and $u_{i,t}$ is an error term that contains firm and time specific fixed effects as follows:

$$u_{i,t} = \mu_i + v_{i,t} \qquad (5)$$

where the $v_{i,t}$ are independent and identically distributed with mean zero and variance σ_v^2. The fixed effects model is selected because it is most appropriate when focusing on a specific set of firms, and inference is restricted to the behavior of this set of firms (Baltagi, 2005). Estimations utilize the first difference of the variables to mitigate problems of serial correlation because some firms exhibit a high degree of persistence in the various measures. The first order autocorrelation coefficients for those firms included in the estimations are as follows: for the price deviation measure, the first order autocorrelation is on average 0.34, but it can reach a maximum of 0.923. For

Table 2. Expected Impacts of Changes in Liquidity on Price Deviations

	Change	Impact on Prices	Impact on Deviation	Expected Sign
ADR Turnover	Increase	P^A increases	Increases	+
	Decrease	P^A decreases	Decreases	
ADR Illiquidity	Increase	P^A decreases	Decrease	-
	Decrease	P^A increases	Increases	
ADR Infrequency	Increase	P^A decreases	Decrease	-
	Decrease	P^A increases	Increases	
Home Turnover	Increase	P^H increases	Decreases	-
	Decrease	P^H decreases	Increases	
Home Illiquidity	Increase	P^H decreases	Increases	+
	Decrease	P^H increases	Decreases	
Home Infrequency	Increase	P^H decreases	Increases	+
	Decrease	P^H increases	Decreases	

Notes: Variables are defined in Section 3A

the liquidity measures, the average first order autocorrelation coefficient is 0.41, but for each measure the maximum values exceed 0.75.

The vector $X'_{i,t}$ contains the set of liquidity measures including turnover, illiquidity, and infrequency for each ADR and its corresponding stock trading in the domestic market. Much empirical evidence suggests that investors value liquidity (see Amihud et al., 2005 for a review). Thus, ADR prices should rise as ADR liquidity increases ultimately leading to an increase in the price deviation measure. Chan et al. (2008a) confirm this relationship for a set of ADRs from developed and emerging markets. Therefore, increases in ADR liquidity (increases in *ADR Turnover* or decreases in *ADR Illiquidity* or *ADR Infrequency*) should be associated with higher price differentials between ADRs and their underlying stocks.

With respect to changes in the liquidity of the underlying stocks, the existing literature documents high illiquidity in Latin America (Lesmond, 2005; Silva & Chavez, 2008) and shows that liquidity is priced as a risk factor for emerging market equities (Bekaert et al., 2007). Consequently, when liquidity increases for the underlying stock (increases in *Home Turnover*; decreases in *Home Illiquidity* or *Home Infrequency*), the price of the underlying stock trading in the home market should increase. The increase in price of the underlying stock should result in a decrease in the price deviation measure. A breakdown of the expected signs for each liquidity measure is included in Table 2.

The vector $Z'_{i,t}$ contains a series of variables to control for conditions that may influence the pricing of ADRs and their underlying stocks. First, the existing literature suggests that because they impede arbitrage, holding costs can partially explain the price differences between ADRs and their underlying stocks (Gagnon & Karolyi, 2010; Grossman et al., 2007). Unlike transaction costs which are incurred only when a purchase/sale is completed, holding costs are incurred every period that an arbitrage position remains open. They include the opportunity cost of capital and idiosyncratic risk exposure (Pontiff, 2006).

To proxy for the opportunity cost of capital, the analysis incorporates a local market interest rate as in Gagnon and Karolyi (2010) who argue that a local market interest rate is a better proxy for the opportunity cost of capital than a U.S. interest rate because it can better capture two dimensions: (a) how binding market conditions would be to short the shares locally if local market shares were relatively overpriced and (b) how hard the U.S. cross-listed shares would be to borrow if they, in turn, were relatively overpriced. The following rates serve as proxies: 30-day Buenos Aires Interbank Offer Rate (BAIBOR) in Argentina, 30-day Interbank Certificate of Deposit Rate (CDI) in Brazil, 30-day Central Bank Discountable Promissory Notes Rate (PDBC) in Chile, and 28-day Equilibrium Interbank Interest Rate (TIIE) in Mexico.Since higher interest rates represent a higher cost of capital immobilized in arbitrage positions, high interest rates should impede arbitrage and therefore be associated with higher price deviations between ADRs and their underlying stocks. DataStream International provides interest rate data for all countries, except Chile, which is obtained from the website of Chile's Central Bank.

In addition, the empirical approach incorporates a proxy for idiosyncratic risk. Idiosyncratic risk reflects components of the arbitrage position that are uncorrelated to the market and any other hedge positions available to the arbitrageur; arbitrageurs are unable to hedge idiosyncratic risk, so they must balance the expected profit from a position against the idiosyncratic risk to which the position exposes them (Pontiff, 2006). Because idiosyncratic risk impedes arbitrage, higher levels of idiosyncratic risk should be associated with larger price deviations between ADRs and their corresponding stocks. We measure idiosyncratic risk using the approach of Gagnon and Karolyi (2010). This approach allows for possible systematic co-movement of the cross-listed and home market share prices over time, with shares of stocks in their respective markets. First, the return difference in the price deviation between an ADR and its underlying stock is defined as the daily difference in the price deviation measure ($Deviation_{i,d}$-$Deviation_{i,d-1}$). Then, the return difference is regressed, within each firm-quarter, on contemporaneous, leading, and lagged, daily U.S. and home market index returns and relevant log currency changes. The model takes the following form:

$$R_{A-H,d} = \alpha + \sum_{i=-1}^{+1} \beta_i^{US} R_{M,d+i}^{US} + \sum_{i=-1}^{+1} \beta_i^{H} R_{M,d+i}^{H} + \sum_{i=-1}^{+1} \beta_i^{FX} R_{M,d+i}^{FX} + \varepsilon_{A-H,d} \quad (6)$$

where $R_{A-H,d}$ is the daily return difference between the

ADR and the home market share, $R^{US}_{M,d+i}$ ($R^{H}_{M,d+i}$) is the U.S. (home) market index return and $R^{FX}_{M,d+i}$ is the currency return of the benchmark currency for the home market relative to the U.S. dollar. The standard deviation of the residuals from estimating this equation (by quarter, using daily data) serves as a proxy for the idiosyncratic risk associated with the arbitrage position.

Finally, the analysis includes controls for uncertainty in U.S. and home market conditions that may impact the price deviations between ADRs and their underlying stocks. The volatility of returns in the U.S. and home markets captures market uncertainty. This volatility is the standard deviation of returns which are in turn calculated as the log difference of the daily average of the Morgan Stanley Capital International (MSCI) index for each country. (Patro (2000) and Fang and Loo (2002) choose the MSCI index to capture market returns). In addition, because some studies document that ADR returns are exposed to exchange rate risk, the volatility of exchange rates completes the set of controls (Bin, Morris, & Chen, 2003; Bae, Kwon, & Li, 2008).

Ⅳ. Empirical Results

Table 3 displays the results from estimating Equation (4). The results provide mixed evidence with respect to the impact of liquidity on price deviations; the mixed results persist even when we include control variables as shown in Column (2). For example, the coefficient on *Home Illiquidity* is positive and statistically significant at the 1% level suggesting that as the illiquidity of shares trading in the home market increases, their price decreases yielding an increase in the price deviation. This differs from the findings of Chan et al. (2008) who find that only liquidity in the host (ADR) market affects ADR mispricing. They argue that the importance of ADR liquidity is not surprising because the deviation is largely determined by U.S. investors who observe the price of the underlying stock and determine the level of the ADR price and consequently the respective deviation based on various factors they face. Because U.S. investors care more about the liquidity in the ADR market than in the home market, ADR liquidity will matter more. The difference in the present results likely arises because the current sample considers only emerging markets while the sample in Chan et al. (2008) is dominated by ADRs from developed markets. Therefore, the current results suggest that investors care about home liquidity when investing in relatively illiquid markets like the four Latin American countries studied here.

However, some results in Table 3 are inconsistent with theoretical predictions. For example, the coefficient on *Home Infrequency* is statistically significant but negative. This coefficient contradicts the notion that investors value liquidity because it implies that increasing illiquidity is consistent with higher stock prices. A possible driving force behind these results is the severe trading infrequency of some stocks. Levy Yeyati, Schmukler, and Van Horen (2008) discuss how trading infrequency can potentially lead to results that are difficult to explain when dealing with price deviations between ADRs and their corresponding stocks. Specifically, the inclusion of observations with no trading in one of the markets may create variations in the daily price deviations that are completely explained by the fact that, in the absence of trading, the last traded price is repeated for non-trading days. In this sample, the price deviation measure is the quarterly average of the daily deviation measure (see Equation 1). The summary statistics from Table 1 indicate that trading infrequency is particularly acute for underlying stocks in Mexico. Therefore, the severe trading infrequency of some stocks may be responsible for the observed anomalies. To assess this possibility, Equation (4) is estimated excluding *High Infrequency Firms*—sixteen firms that exhibit trading infrequency values that are, on average, 10% or higher, for either the ADR or the corresponding stock in the home market. Analysis for the *High Infrequency Firms* is available from the author upon request.

The last column of Table 3 displays evidence that changes in liquidity significantly impact the deviations that arise between ADRs and their corresponding stocks. *ADR Turnover* exhibits, as expected, a positive coefficient such that when turnover increases, ADR prices rise and exert upwards pressure on the price deviations. The estimation excludes the trading infrequency variables because firms included do not exhibit high levels of trading infrequency in either the ADR or the underlying stock. In addition, the results suggest that when turnover at home increases, the price of the underlying stock increases driving down the price deviation as supported by the negative

and statistically significant coefficient on *Home Turnover*. The results also indicate that increases in *ADR Illiquidity* are associated with decreases in price deviation. This finding is in line with the Chan et al. (2008a) in that higher ADR liquidity is associated with a higher ADR premium. Surprisingly, given the full sample results, the coefficient on *Home Illiquidity* is not statistically significant at any conventional level.

In general, the results in Table 3 support the notion that liquidity influences the mispricing of ADR issues from Argentina, Brazil, Chile, and Mexico. In most cases, the results are consistent with the idea that investors value liquidity. Despite the fact that ADR issuing firms tend to be the largest firms in the domestic market, the findings highlight the importance of accounting for trading infrequency of the underlying shares when dealing with emerging market stocks as failure to do so can provide counterintuitive results. Moreover, the results indicate that investors are concerned with liquidity in both the home and host markets when dealing ADR issues from emerging markets with low liquidity such as the four Latin American markets considered here. One potential problem with the estimation of Equation (4) is that the sample period spans turmoil in financial markets associated with the global

Table 3. Panel Regressions: Impact of Liquidity on Price Deviations in Latin America

	All	All	Excluding High Infrequency Firms
ADR Turnover	-0.002	0.005	0.075***
	(0.015)	(0.021)	(0.018)
Home Turnover	0.001*	-0.090	-0.051***
	(0.001)	(0.092)	(0.017)
ADR Illiquidity	-0.059	-0.056	-0.111*
	(0.085)	(0.083)	(0.057)
Home Illiquidity	0.008***	0.009***	0.031
	(0.003)	(0.003)	(0.049)
ADR Infrequency	0.067	0.081	
	(0.065)	(0.063)	
Home Infrequency	-0.065**	-0.067**	
	(0.027)	(0.027)	
Idiosyncratic Risk		0.118	-0.019
		(0.199)	(0.123)
Interest Rates		-0.020	0.021*
		(0.027)	(0.012)
Home Volatility		0.080*	-0.007
		(0.043)	(0.029)
U.S. Volatility		-0.384*	-0.325***
		(0.204)	(0.120)
FX Volatility		-0.018	0.226***
		(0.037)	(0.059)
Constant	-0.0004***	-0.0003	-0.0001
	(0.000)	(0.000)	(0.000)
R^2	3.80%	5.50%	9.5%
# of Observations	2020	2004	1620

Notes: Quarterly data beginning Quarter I 2003 to Quarter IV 2010. Panel data regression with firm-level fixed effects of Deviation (the ADR price relative to the home share price adjusted for currency fluctuations and for the ADR conversion ratio when necessary) on liquidity variables including ADR and Home Turnover (the number of shares traded relative to number of shares outstanding), ADR and Home Illiquidity (the ADR/Home return relative to the dollar volume traded), ADR and Home Infrequency (defined as the number of days an ADR/stock does not trade relative to the total number of trading days in the quarter), and a number of control variables including holding costs (interest rates and idiosyncratic risk) and market uncertainty conditions. All variables are entered in first differences to mitigate problems of serial correlation. Robust standard errors are shown in parentheses. Symbols *, **, *** represent statistical significance at the 10%, 5%, and 1% levels respectively.

financial crisis of 2008. Levy Yeyati et al. (2008) examine liquidity in emerging markets during times of crisis and document that crises are consistent with higher trading activity, falling stock prices, and increases in trading costs as captured by the Amihud (2002) illiquidity variable. Therefore, if liquidity influences the price deviations that arise between ADRs and their underlying stocks, the aforementioned results may be an artifact of effects from the crisis. To ensure that this is not the case, the analysis separates the sample into pre-crisis and crisis/post-crisis periods. Quarter II is selected as the beginning of the crisis because Dooley and Hutchison (2009) suggest that emerging markets, including Latin America, were insulated or decoupled from the U.S. financial crisis until May 2008 when conditions began deteriorating significantly.

Table 4 reports the results from estimating Equation (4) in two periods: pre-crisis and crisis/post-crisis periods. Not surprisingly, the estimates differ across sub-periods. In the pre-crisis period, consistent with the findings in Table 4, *ADR Turnover* and *Home Turnover* influence price deviations. The pre-crisis results hold across different crisis definition dates. For robustness, we test two alternative quarters as the beginning of the crisis period: QI of 2008 is consistent with the official beginning of the recession as defined by the National Bureau of Economic Research and Quarter III of 2008 captures the turmoil in markets as a result of the Lehman bankruptcy. However, in the crisis/post-crisis period, most of the liquidity variables

Table 4. Panel Regressions: Impact of Liquidity on Price Deviations in Latin America

	Pre-Crisis	Crisis/Post-Crisis
ADR Turnover	0.062***	-0.005
	(0.016)	(0.228)
Home Turnover	-0.051***	-0.052
	(0.012)	(0.178)
ADR Illiquidity	-0.048	0.008
	(0.040)	(0.036)
Home Illiquidity	0.045	-0.390**
	(0.035)	(0.166)
Idiosyncratic Risk	0.293	-0.159
	(0.221)	(0.140)
Interest Rates	0.004	-0.067**
	(0.015)	(0.025)
Home Volatility	-0.047	-0.082
	(0.038)	(0.170)
U.S. Volatility	-0.046	0.469***
	(0.181)	(0.144)
FX Volatility	0.142***	0.716***
	(0.050)	(0.000)
Constant	-0.0004***	-0.0001
	(0.000)	(0.000)
R^2	7.0%	13.35%
# of Observations	1,025	766

Notes: Quarterly data. Pre-crisis period extends from QI 2003 to QII 2008. Post-crisis period extends from QIII 2008 to Q IV 2010. Panel data regression with firm-level fixed effects of Deviation (the ADR price relative to the home share price adjusted for currency fluctuations and for the ADR conversion ratio when necessary) on liquidity variables including ADR and Home Turnover (the number of shares traded relative to number of shares outstanding), ADR and Home Illiquidity (the ADR/Home return relative to the dollar volume traded), ADR and Home Infrequency (defined as the number of days an ADR/stock does not trade relative to the total number of trading days in the quarter), and a number of control variables including holding costs (interest rates and idiosyncratic risk) and market uncertainty conditions. All variables are entered in first differences to mitigate problems of serial correlation. Excludes "High Infrequency Firms" which are those firms that exhibit trading infrequency higher than 10%, on average for either the ADR or the underlying stock. The symbols *, **, *** represent statistical significance at the 10%, 5%, and 1% levels respectively. Robust standard errors are shown in parentheses.

do not exert a discernible influence on the price deviation measure. The only exception is for the variable *Home Illiquidity* which exhibits a negative and statistically significant coefficient. These results are at odds with theoretical predictions because an increase in home illiquidity should lead to lower home share prices and consequently higher price deviations. Therefore, the findings indicate that the relationship between liquidity and ADR mispricing was affected but not created by the effects of the global financial crisis. Liquidity changes in both ADRs and their corresponding stocks drive price deviations in the pre-crisis period. In addition, the results suggest that in times of crisis, price deviations are more likely driven by market uncertainty as most of the control variables are statistically significant in the crisis/post-crisis period.

Finally, this paper considers the following question: are the effects of liquidity on price deviations asymmetric? That is, do decreases in liquidity affect price deviations differently than equivalent liquidity increases? Testing for asymmetric liquidity effects on the price deviations between ADRs and their underlying stocks begins with the definition of a binary variable that takes on the value of 1 if there is a liquidity decrease and 0 otherwise. Each liquidity measure corresponds to a different binary variable. Next, an asymmetry variable captures the interaction of each binary variable with its respective liquidity measure. As an example, consider the variable *ADR Illiquidity*. Note that the full model should contain six binary (D_1, D_2,$\cdots D_6$) and asymmetry ($Asymmetry_1$, $Asymmetry_2$, $\cdots$, $Asymmetry_6$) variables (for *ADR Turnover*, *Home Turnover*, *ADR Illiquidity*, *Home Illiquidity*, *ADR Infrequency*, and *Home Infrequency*, respectively). First, a binary variable, *D*, takes on the value of 1 when *Δ(ADR Illiquidity)* is positive (consistent with a decrease in liquidity) and 0 otherwise. Then, the interaction (product) of *D* and *Δ(ADR Illiquidity)* yields *Asymmetry*. The following equation tests whether the impact of *ADR Illiquidity* on price deviations is asymmetric:

A test of asymmetry is equivalent to testing that β_3 is statistically significant, irrespective of the sign of the coefficient. As discussed by Ozer-Balli and Sørensen (2012), the dummy variable *D* is included in the estimation to ensure that the significance of β_3 is not due to the omission of the dummy variable since the dummy is related to the interaction term by construction. The response of price deviations to changes in liquidity will be β_2 when *Δ(ADR Illiquidity)* is negative and ($\beta_2 + \beta_3$) when *Δ(ADR Illiquidity)* is positive. If β_2 is negative and statistically significant but β_3 is not statistically different from zero, then there is no asymmetry. Increases and decreases in *ADR Illiquidity* influence the price deviation measure in a similar fashion. However, if β_3 is statistically significant, then the impact of liquidity on the price deviations that arise between ADRs and their underlying stocks is asymmetric, and the magnitude of the relationship varies based on whether liquidity is increasing or decreasing. In the cases where only the coefficient on the interaction term is statistically significant (β_3 is significant but β_2 is not), then *decreases only* in liquidity affect the price deviations.

The estimates from testing for asymmetric effects are displayed in Table 5. The findings continue to indicate that liquidity matters for price deviations; and in several cases, the effects are asymmetric. For example, the relationship between *ADR Turnover* and price deviations persists; while the coefficient on this variable is not statistically different from 0, the corresponding *Asymmetry* variable is positive and statistically significant. This is consistent with the notion that price deviations change only as a result of a decrease in *ADR Turnover*. In addition, the same relationship is found for *Home Turnover* albeit the coefficient is negative in this case. Finally, the coefficient on *ADR Illiquidity* is negative and statistically significant at the 5% level. In this case, no evidence of asymmetric effects is visible. In all, the results support the notion that liquidity matters for ADR mispricing. As measured by *Turnover*, the effects of liquidity on price deviations are asymmetric with decreases driving the results. Interestingly, the asymmetric effect is observed for both the ADR and its corresponding stock trading in the home market. Thus, it appears that when ADRs originate from environments of low domestic liquidity like the four markets considered here, decreases in liquidity occurring in either the home or foreign markets influence price differentials between ADRs and their corresponding stocks.

$$Deviation_{i,t} = \alpha + \beta_1 D + \beta_2 \Delta ADR\ \ Illiquidity_{i,t} + \beta_3 Asymmetry_{i,t} + Z'_{i,t}\gamma + u_{i,t} \quad (6)$$

Table 5. Panel Regressions: Asymmetric Impact of Liquidity on Price Deviations in Latin America

D_1-ADR Turnover	0.0004
	(0.001)
ADR Turnover	0.025
	(0.033)
Asymmetry1-ADR Turnover	0.087***
	(0.031)
D2-Home Turnover	0.000
	(0.001)
Home Turnover	0.020
	(0.038)
Asymmetry2-Home Turnover	-0.077**
	(0.035)
D3-ADR Illiquidity	0.000
	(0.000)
ADR Illiquidity	-0.092**
	(0.042)
Asymmetry3-ADR Illiquidity	-0.026
	(0.052)
D4-Home Illiquidity	0.001*
	(0.001)
Home Illiquidity	0.001
	(0.090)
Asymmetry4-Home Illiquidity	0.030
	(0.088)
Idiosyncratic Risk	-0.011
	(0.127)
Interest Rates	0.020
	(0.013)
Home Volatility	-0.006
	(0.030)
U.S. Volatility	-0.337***
	(0.119)
FX Volatility	0.225***
	(0.064)
Constant	-0.001
	(0.000)
R^2	9.9%
# of Observations	1620

Notes: Panel data regression with firm-level fixed effects of Deviation (the ADR price relative to the home share price, adjusted for currency fluctuations and for the ADR conversion ratio when necessary) on liquidity variables including: ADR and Home Turnover (the number of shares traded relative to number of shares outstanding), ADR and Home Illiquidity (the ADR/Home return relative to the dollar volume traded), and ADR and Home Infrequency (defined as the number of days an ADR/stock does not trade relative to the total number of trading days in the quarter) and a number of control variables including holding costs (interest rates and idiosyncratic risk) and market uncertainty conditions. Each Di variable represents a binary variable that takes on the value of 1 if the respective variable exhibits a decrease in liquidity and 0 otherwise. Each Asymmetryi variable represents the interaction of Di with its respective liquidity variable. Excludes "High Infrequency Firms" which are those firms that exhibit trading infrequency higher than 10%, on average, for either the ADR or the underlying stock.
Robust standard errors are shown in parentheses. Symbols *, **, *** represent statistical significance at the 10%, 5%, and 1% levels respectively.

V. Conclusions

This paper examines whether price deviations that arise between ADRs and their underlying stocks trading in four Latin American markets can be explained by changes in liquidity. The results highlight the importance of accounting for trading infrequency when examining emerging market stocks. Trading infrequency is such a severe problem for some Latin American stocks that it can significantly influence estimates of the impact of liquidity on price deviations. The findings in this paper also suggest that for ADR issues where domestic liquidity is low as in the Latin American markets considered here, investors are concerned with liquidity in the home market in addition to the host market. The results from panel regressions with firm-level fixed effects reveal a relationship between liquidity—of both ADRs and their corresponding stocks—and ADR mispricing even after controlling for holding costs and market uncertainty. Furthermore, this relationship is not an artifact created by turmoil in financial markets during the 2008 global financial crisis. The findings in this paper do indicate that for ADR issues from Latin America, the relationship between liquidity and price deviations was stronger in the tranquil period before mid-2008. Finally, this paper finds that the impact of liquidity on the price deviations that arise between ADRs and their corresponding stocks is often asymmetric for these four Latin American countries. Decreases in liquidity of both the ADR and its underlying stock exert a stronger impact on prices than equivalent increases. Overall, the findings support the idea that liquidity in both the home and host markets matters for price deviations between ADRs and their corresponding stocks trading in Latin American markets.

References

Alaganar, V.T., & Bhar, R. (2001). Diversification gains from American Depositary Receipts and foreign equities: Evidence from Australian stocks. *Journal of International Financial Markets, Institutions, and Money, 11*, 97-113.

Amihud, Y. (2002). Illiquidity and stock returns: Cross section and time series effects. *Journal of Financial Markets, 5*, 31-56.

Amihud, Y., & Mendelson, H. (1986a). Asset pricing and the bid-ask spread. *Journal of Financial Economics, 17*(2), 223-249.

Amihud, Y., & Mendelson, H. (1986b). Liquidity and stock returns. *Financial Analysts Journal, 42*, 43-48.

Amihud, Y., & Mendelson, H., & Pedersen, L.H. (2005). Liquidity and asset prices. *Foundations and Trends in Finance, 1*(4), 269-364. doi.org/10.1561/0500000003

Aquino, K.P., & Poshakwale, S. (2006). Price determinants of American Depositary Receipts (ADR): a cross-sectional analysis of panel data. *Applied Financial Economics, 16,* 1225-1237.

Arnold, T., Nail, L., & Nixon, T.D. (2004). Do ADRs enhance portfolio performance for a domestic portfolio? Evidence from the 1990s. *Research in International Business and Finance*, *18*, 341-359.

Bae, S.C., Kwon, T.H., & Li, M. (2008). Foreign exchange rate exposure and risk premium in international investments: Evidence from American Depositary Receipts. *Journal of Multinational Financial Management*, *18*, 165-179.

Baltagi, B. H. (2005). *Econometric analysis of panel data* (3rd ed.). West Sussex, England: John Wiley & Sons.

Bartram, S.M., & Bodnar, G.M. (2009). No place to hide: The global crisis in equity markets in 2008/2009. *Journal of International Money and Finance*, *28*, 1246-1292.

Bekaert, G., & Harvey, C.R. (2000). Foreign speculators and emerging equity markets. *Journal of Finance*, *55*, 565-614.

Bekaert, G., & Harvey, C.R. (2003). Emerging markets finance. *Journal of Empirical Finance*, *10*, 3-55.

Bekaert, G., & Harvey, C.R., Lumsdaine, R.L. (2002). The dynamics of emerging market equity flows. *Journal of International Money and Finance*, *21*, 295-350.

Bekaert, G., & Harvey, C.R., Lundblad, C. (2007). Liquidity and expected returns: Lessons from emerging markets. *Review of Financial Studies*, *20*, 1783-1831.

Bin, F., Blenman, L. P., & Chen, D. (2004). Valuation impact of currency crises: Evidence from the ADR market. *International Review of Financial Analysis*, *13*, 411-442.

Bin, F., Morris, G.B., & Chen, D. (2003). Effects of exchange-rate and interest-rate risk on ADR pricing behavior. *North American Journal of Economics and Finance*, *14*, 241-262.

Brennan, M. J., & Subrahmanyam, H. (1996). Market microstructure and asset pricing: On the compensation for illiquidity in stock returns. *Journal of Financial Economics*, *41*, 441-464.

Cechetti, S. G. (2009). Crisis and Responses: The Federal Reserve in the early stages of the financial crisis. *Journal of Economic Perspectives*, *23*, 51-75.

Chalmers, J.M.R., & Kadlec, G.B. (1998). An empirical examination of the amortized spread. *Journal of Financial Economics*, *48*, 159-188.

Chan, J.S.P., Hong, D., & Subrahmanyam, M.G. (2008a). A tale of two prices: Liquidity and asset prices in multiple markets. *Journal of Banking & Finance*, *32*, 947-960.

Chan, J.S.P., Jain, R., & Xia, Y. (2008b). Market segmentation, liquidity spillover, and closed-end country fund discounts. *Journal of Financial Markets*, *11*, 377-399.

Choi, Y. K., & Kim, D. (2000). Determinants of American depositary receipts and their underlying stock returns: Implications for international diversification. *International*

Review of Financial Analysis, *9*, 351-368.

Chordia, T., Huh, S., & Subrahmanyam, A. (2009). Theory-based illiquidity and asset pricing. *Review of Financial Studies*, *22*(9), 3629-3668.

Datar, V.T., Naik, N.Y., & Radcliffe, R. (1998). Liquidity and stock returns: An alternative test. *Journal of Financial Markets*, *1*, 205-219.

Dooley, M., & Hutchison, M. (2009). Transmission of the U.S. subprime crisis to emerging markets: Evidence on the decoupling-recoupling hypothesis. *Journal of International Money and Finance*, *28*(8), 1331-1349.

Eichler, S., Karmann, A., & Maltritz, D. (2009). The ADR shadow exchange rate as an early warning indicator for currency crises. *Journal of Banking and Finance*, *33*(11), 1983-1995.

Elliot, G., Rothenberg, T. J., & Stock, J.H. (1996). Efficient tests for an autoregressive unit root. *Econometrica*, *64*(4), 813-836.

Ely, D., Salehizadeh, M. (2001). American Depositary Receipts. An analysis of international stock price movements. *International Review of Financial Analysis*, *10*, 343-363.

Fang, H., & Loo, J.C.H. (2002). Pricing of American depositary receipts under market segmentation. *Global Finance Journal*, *12*, 237-252.

Foerster, S.R., & Karolyi, G.A. (1998). Multimarket trading and liquidity: A transaction data analysis of Canada-US interlistings. *Journal of International Financial Markets, Institutions and Money*, *8*, 393-412.

Gagnon, L., & Karolyi, G.A. (2010). Multi-market trading and arbitrage. *Journal of Financial Economics*, *97*, 53-80.

Grossman, A., Ozuna, T., & Simpson, M.W. (2007). ADR mispricing: Do costly arbitrage and consumer sentiment explain the price deviation? *Journal of International Financial Markets, Institutions, & Money*, *17*, 361-371.

Hasbrouck, J. (2009). Trading costs and returns for U.S. equities: Estimating effective costs from daily data. *Journal of Finance*, *64*(3), 1445-1477.

Hsiao, C. (2003). *Analysis of panel data* (2nd ed.). New York, NY: Cambridge University Press.

Hsu, J., & Wang, H. (2008). Why do price spreads between domestic shares and their ADRs vary over time? *Pacific Economic Review*, *13*, 473-491.

Hunter, D. (2006). The evolution of stock market integration in the post-liberalization period—A look at Latin America. *Journal of International Money and Finance*, *25*, 795-826.

Huybens, E., & Smith, B.D. (1999). Inflation, financial markets and long-run real activity. *Journal of Monetary Economics*, *43*, 283-315.

Jiang, A. X. (1998). Diversification with American depositary receipts: The dynamics and pricing factors. *Journal of Business, Finance and Accounting*, *25*, 683-699.

J. P. Morgan/Chase. (2012). *ADR liquidity-There's more than meets the eye*. DR Investor Insights.

Kadiyala, P., & Kadiyala, P. (2004). ADRs as leading indicators of exchange rates. *Emerging Markets Review*, *5*, 83-107.

Karolyi, G.A. (1998). Why do companies list shares abroad? A survey of the evidence and its managerial implications. *Financial Markets, Institutions and Instruments*, *7*, 1-60.

Kyle, A. S. (1985). Continuous auctions and insider trading. *Econometrica*, *53*(6), 1315-1335.

Lesmond, D. A. (2005). Liquidity of emerging markets. *Journal of Financial Economics*, *77*, 411-452.

Lesmond, D.A., Ogden, J.P., & Trzcinka, C.A. (1999).. A New Estimate of Transaction Costs. *Review of Financial Studies*, *12*(5), 1113-1141.

Levy Yeyati, E., Schmukler, S. L., & Van Horen, N. (2008). Emerging market liquidity and crises. *Journal of the European Economic Association*, *6*(2), 668-682.

Levy Yeyati, E., Schmukler, S. L., & Van Horen, N. (2009). International financial integration through the law of one price: The role of liquidity and capital controls. *Journal Financial Intermediation*, *18*, 432-463.

Liang, Y., & Mougoue, M. (1996). The pricing of foreign exchange risk: Evidence from ADRs. *International Review of Economics and Finance*, *5*, 377-385.

Miller, D. P. (1999). The market reaction to international cross-listing: Evidence from depositary receipts. *Journal of Finance*, *42*, 483-510.

Ødegaard, B.A. (2007). Price differences between equity classes. Corporate control, foreign ownership or liquidity? *Journal of Banking and Finance*, *31*(12), 3621-3645.

Officer, D.T., & Hoffmeister, J.R. (1987). ADRs: A substitute for the real thing? *Journal of Portfolio Management*, *13*, 61-65.

Ozer Balli, H. & Sørensen, B. (2012). Interaction effects in econometrics. *Empirical Economics*, *45*, 583-603.

Patro, D.K. (2000). Return behavior and pricing of American depositary receipts. *Journal of International Financial Markets and Institutions*, *9*, 43-67.

Pontiff, J. (2006). Costly arbitrage and the myth of idiosyncratic risk. *Journal of Accounting and Economics*, *42*, 35-52.

Silva, A. C., & Chávez, G.A. (2008). Cross-listing and liquidity in emerging market stocks. *Journal of Banking & Finance*, *32*(3), 420-433.

Wahab, M., & Khandwala, A. (1993). Why not diversify internationally with ADRs? *Journal of Portfolio Management*, *19*, 75-82.