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Financial Contagion and Market Liquidity: Evidence from the Asian Crisis

Shantaram P Hegde* and Rupendra Paliwal**

Models of financial crisis and contagion predict that an economic crisis turns into a crisis of market liquidity in the presence of borrowing constraints, information asymmetry and risk aversion. Based on the firm-level data on a sample of exposed and unexposed US stocks to the Asian currency crisis, we find a significant increase (decrease) in the crisis period bid-ask spreads (depth) and their volatilities for both the groups. While our results underscore the imprints of flight to quality, we detect little causal patterns in liquidity innovations. An important implication of our findings, as evidenced by the recent crisis, is that regulatory response to enhance liquidity during a crisis should not be limited to the industries and markets directly exposed to the crisis. Finally, we find that the deterioration in market liquidity provides a partial explanation for the crisis-induced abnormal returns.

Introduction

Theoretical models of economic crises and financial contagion highlight that exogenous shocks are characterized by sharp price declines, increased return volatility, higher correlation in returns across markets and countries, and reduced trading liquidity (*see* Kyle and Xiong, 2001 and Yuan, 2004). They predict that the original crisis may spill over to firms and national markets that are fundamentally unrelated, particularly those with 'more liquidly traded' assets, for many reasons, such as increased risk aversion of investors, binding borrowing (margin) constraints faced by the traders, information asymmetry, hedging demand, and irrational investor behavior. In this study, we ask whether these steep price falls, spikes in return volatility and inflated return correlations are associated with firm-level trading liquidity of stocks—the level of liquidity, its volatility and co-movement across a sample of US stocks. While most of the crisis studies do not examine the transaction liquidity implications of a crisis-induced portfolio rebalancing, Bookstaber (2000) shows that the confluence of leverage, portfolio risk and market illiquidity precipitates a cascade of falling prices, portfolio liquidations and declining market liquidity.

We focus on an extreme (left-tail) liquidity event—a financial market crisis. Underscoring the central role of market liquidity in amplifying the original crisis, Bookstaber (2000, p. 22) observes, "A market crisis is a crisis of liquidity far more than it is a crisis born of information."[1]

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[1] Richard M Bookstaber was the Head of Risk Management at Salomon Smith Barney in mid-1998, when Long-Term Capital Management (LTCM) faced a severe liquidity crisis. Bookstaber (1999) points out that in a normal market, a price drop attracts buyers (liquidity suppliers) and dissuades sellers (liquidity demanders). But under

Yet, the available empirical evidence on economic crises and trading liquidity is largely limited to their negative wealth effects, how they exacerbate return volatility, increase correlation in returns across asset classes and markets, and 'aggregate' market liquidity of stocks and bonds (*see* Forbes and Rigobon, 2002; Chordia *et al*., 2005; and Liu, 2006). There is little evidence on the behavior of trading liquidity of individual stocks (micro-liquidity), although there are good reasons to believe that sharp declines in asset returns in a market turmoil would cause parallel dramatic changes in transaction liquidity of the individual stocks.

As the models reviewed above imply, the dramatic negative returns on exposed stocks caused by the adverse economic shock induce leveraged dealers and investors to sell their holdings, thus increasing order imbalances and the level and variance of liquidity costs of individual stocks. Second, increased return volatility accompanying sharp price declines triggers market-maker capital constraints and increases inventory and solvency risks, thereby curtailing the supply of liquidity. Third, portfolio rebalancing induced by borrowing constraints and increased risk aversion of traders and dealers would increase liquidity spillovers and co-movement in liquidity across all stocks. Fourth, understanding the differences in liquidity innovations between individual stocks exposed and unexposed to the crisis would help craft effective regulatory response to mitigate the liquidity crunch.

Our objective is to fill this gap by empirically investigating not only the broad strokes but also the finer details of liquidity innovations during a recent economic crisis. Specifically, we examine the following questions about the behavior of microstructure liquidity of a sample of individual US stocks during the Asian currency crisis of 1997. First, did the Asian crisis affect: (a) the level of liquidity, (b) the volatility of liquidity, and (c) the co-movement of liquidity of US stocks? Second, are these liquidity stocks unique to the stocks 'directly exposed' to the crisis, or, are they systemic in nature—i.e., spillover to even the 'unexposed' (i.e., fundamentally unrelated) stocks? What are the cross-market causal patterns in liquidity innovations? The intent here is to look "under the hood" of aggregate market liquidity and examine the differential liquidity behavior of the exposed and unexposed group of stocks. Finally, does the concurrent increase in the level and variance of liquidity costs offer a partial explanation for cross-sectional variations in crisis-period abnormal returns? This question is motivated by the recent evidence on the linkages between expected stock returns, liquidity costs and liquidity risk.

Ideally, we would need to trade and quote data on Asian currencies and equities to address the above questions about the behavior of firm-level trading liquidity during the Asian crisis. Unfortunately, we could not find transaction data for these markets for the period surrounding the crisis. Our second preference was to use the US equity market data for which we have the market microstructure data, even though this market is far removed from the epicenter of the crisis. We defend the choice of this substitute market on the ground that contagion theories predict that the ripple effects of the crisis are likely to spread to the more

a market crisis, the price drop reduces liquidity supply (potential buyers) because of the fear of further pricedrops and greater volatility. It increases liquidity demand as forced liquidations to meet margin calls lead to further liquidity-induced price falls. Even those who supply liquidity (i.e., buyers such as speculators and hedge funds) in a normal price decline would turn into liquidity demanders (i.e., sellers) in the face of a cascade of price falls, and the financial liquidity crisis degenerates into a market liquidity crisis.

liquid markets all over the globe, thus exposing the US equity markets. We divide the US equity sample into exposed and unexposed stocks as a reasonable way to distinguish between the first-round economic shock effects and the second-round liquidity-induced effects of the crisis. We complement this analysis by examining the difference between liquid/less liquid and risky/less risky shares to identify the likely illiquidity effects of borrowing constraints, risk aversion, and information asymmetry. We use high frequency data-trade and quote (TAQ) to capture information on short-run market interactions that may be either difficult to detect or absent in lower frequency data.

Our study is similar in spirit to Chordia *et al.* (2005) who focus on liquidity dynamics during the financial crises of the 1990s at the macro level by analyzing flight to quality or safety from the stock market to the government bond market. However, examining market-wide liquidity measures tends to mask important firm-level innovations. We extend their study by presenting micro-level evidence on liquidity innovations in both exposed and unexposed stocks, more risky and less risky stocks, and more liquid and less liquid stocks during the Asian crisis.

Empirical Predictions

Related Literature on Financial Contagion

There is a growing body of literature that examines financial contagion as the transmission of an economic shock from one or a few institutions or a particular economic region to the industry or economy at large in the form of rapid spillover of falling prices, increased volatility, increased correlation of price changes, and declining market liquidity across assets and markets.[2] These studies discuss several propagation mechanisms for financial contagion. Some view contagion as an 'irrational' phenomenon, while others model it as a 'rational' equilibrium phenomenon. The irrational approach assumes that unlike small negative returns, extreme (left tail) events induce investors to ignore economic fundamentals and dump all assets, leading to excess volatility and even panic.[3] In contrast, a common rational approach views contagion as a byproduct of information asymmetry, risk aversion and informed investor borrowing constraints (*see* Lang and Stulz, 1992; Claessens *et al*., 2001; and Calvo, 2004).

Yuan (2004) presents a recent example of a rational expectations equilibrium model in which a small adverse shock to the fundamentals lowers the price of a risky asset, which may limit the ability of informed investors to engage in arbitrage due to borrowing constraints. Constrained trading by informed traders makes the falling market price increasingly uninformative. Unable to separate liquidity selling from informed selling, uninformed

[2] There is no consensus on the definition of contagion in the literature. Some researchers have described contagion as a significant increase in the probability of crisis in one country conditional on a crisis occurring in another country. Studies based on this definition have focused on the collapse of exchange rates. Others define contagion as a significant increase in co-movements of prices and quantities across markets, conditional on a crisis occurring in one market or a group of markets. To distinguish this co-movement from the normal interdependence of stock markets, some studies have further qualified this definition by adding that contagion occurs when the co-movement cannot be explained by fundamentals. Most empirical studies in this line of research have focused on cross-correlation between stock returns in different countries before and during the crisis period.

[3] Masson (2000) shows how a crisis in one country could shift investors' expectations from a good to bad equilibrium for another country and thereby cause a crash in the second economy.

investors demand a large premium to hold risky assets, which exacerbates the price decline and transforms the initial small shock into a market crisis. Extending this model to an economy with two independent and identical risky assets, she demonstrates that the borrowing constraint can spread the price fall from one asset market to the unrelated second asset market, thus transforming an idiosyncratic shock into a contagion.

Models of financial contagion typically stress the central role of the endogenous crisis in financial liquidity (wealth shocks) in propagating the initial economic shock across assets and markets. For instance, Kyle and Xiong (2001) model contagion as endogenously determined by the capitalizations and trading activities of all the market participants. While most of the studies do not investigate the market microstructure implications of crisis-induced portfolio rebalancing, Bookstaber (2000) examines the confluence of the extent of leverage employed by the fund, the fundamental risk of its portfolio and the market illiquidity of its holdings in transforming an exogenous macroeconomic shock to a hedge fund into a market crisis. He concludes that low market liquidity is at the root of financial crisis.[4] Recently, Brunnermeier and Pedersen (2005) have noted that under certain conditions, market liquidity and funding liquidity are mutually reinforcing and may lead to liquidity spirals. Forbes (2004) finds that during the Asian crisis, more liquid stocks had significantly lower returns, suggesting that margin calls and other liquidity needs forced investors to sell assets in markets not directly affected by the crisis.[5]

In the literature on market microstructure, Chordia *et al.* (2000), Hasbrouck and Seppi (2001), and Huberman and Halka (2001) observe that illiquidity costs of the most stocks are positively related to the aggregate market illiquidity—commonality in liquidity. Moreover, liquidity-enhanced asset pricing models of Pastor and Stambaugh (2003), Acharya and Pedersen (2005) and Liu (2006) emphasize that investors demand a liquidity premium for holding assets with low returns when the overall market is illiquid and assets with less liquidity in market downturns. They conclude that liquidity risk (i.e., a stock's return and liquidity sensitivity to market-wide liquidity) is an important source of priced risk for asset pricing. Chordia *et al.* (2005) report that 'aggregate' US stock and bond market liquidity fell during the financial crises of the 1990s (also *see* Liu, 2006). Brunnermeier and Pedersen (2005) argue that dealers are more likely to face a capital constraint when a sharp drop in market price of securities reduces the value of their loan collaterals. When they encounter margin calls and potential inventory funding problems, these market-makers, who provide liquidity under normal market conditions, demand liquidity in a market crisis. This results in, both, a sharp increase in the demand for liquidity and a decrease in the provision of

[4] Under regulation T, the maximum leverage US investors can use to fund equity positions (i.e., equity margin requirements) is limited to two to one, total assets to equity. The initial margin is usually 50% of the value of shares and the maintenance margin is 25%. Interest rates on margin loans are 1 to 2% above the prime interest rate. Other securities have their own margin requirements. For instance, margins for treasury bonds are 10%. In contrast, futures margin requirements are set by the futures exchanges and vary widely. For instance, typical margin requirements for Eurodollar futures, US treasury bond futures and stock index futures are approximately 0.03%, 1.8% and 7%, respectively (*see* Perold, 1999).

[5] For a large global sample of stocks, Forbes (2004) uses the following two proxies for market liquidity: more liquid stocks are those for which returns are non-zero in at least 75% of the pre-crisis trading days, and the percent of shares traded to shares outstanding.

liquidity, precipitating a dramatic increase in liquidity costs. Further, as the financial constraints of intermediaries affect all securities, the increase in liquidity costs would be accompanied by an increase in the co-movement of illiquidity.

Hypotheses

Our objective is to extend the previous work based primarily on stock returns, return volatility, and correlation of returns across stocks surrounding an exogenous market-wide economic shock to an analysis of changes in the level of trading liquidity, liquidity uncertainty, and correlation of liquidity among stocks at the firm level. Specifically, we study the following predictions and implications concerning the role of stock market liquidity in financial contagion surrounding the Asian currency crisis of 1997. First, a straightforward prediction is that sharp drops in stock prices in a market crisis would cause a flood of liquidation orders across the board, whether due to increased risk aversion, binding borrowing (margin) constraints, information asymmetry, or herd-like investor behavior. Even speculators, hedge funds, and market makers, who supply liquidity in normal markets, may demand immediacy in a crisis because they need to liquidate their positions to meet margin calls in the face of rapidly declining price spirals. The resulting increase in demand for liquidity in the face of declining liquidity supply would cause a decrease in the level of liquidity and an increase in the volatility of liquidity for stocks 'directly exposed' to the economic crisis. We term these deteriorations in the transaction liquidity of the directly exposed stocks the 'liquidity crunch' hypothesis.

Second, since crisis-induced liquidations are likely to spread to assets that are fundamentally unrelated in the presence of risk aversion, information asymmetry and borrowing constraints faced by intermediaries and informed traders, we expect that even firms that are 'not directly exposed' to the crisis would suffer a decline in market liquidity and an increase in the variability of liquidity. Further, we expect the crisis-induced reshuffling of portfolios by dealers and investors to increase the co-movement in liquidity of the exposed and unexposed stocks. We call these spillover effects the 'liquidity contagion' hypothesis. Moreover, since the price drop, return volatility spike and increase in return correlation caused by the crisis would be relatively greater for the exposed stocks, we would expect a sharper increase in the demand for liquidity coupled with a steeper drop in the supply of liquidity for the exposed stocks. This leads us to predict more pronounced changes in the level, volatility and correlation of liquidity for the exposed stocks as compared with the unexposed stocks.

Third, it is widely known that an adverse economic shock causes 'noise traders' to flee to hitherto more liquid and less volatile stocks, dubbed as 'flight to liquidity' and 'flight to quality'. A relevant issue is how the trades originating from leveraged traders would accentuate or counter these trade currents, and how capital-constrained dealers would reallocate their market-making between liquid and volatile stocks. As the previously reviewed models show, the dynamics of the trading traffic in a market crisis vary depending upon the interplay among risk aversion, borrowing constraints, and information asymmetry. For instance, speculators might liquidate more liquid holdings in their portfolio to meet margin calls or choose to sell more volatile stocks to reduce the odds of further margin calls. Similarly, intermediaries might curtail their dealing in more volatile issues to reduce the chances of hitting capital constraints and refocus their market-making in less volatile and more liquid stocks. But it is difficult to find data on capital constraints, margin sales, risk preferences, and informational frictions among investors. Therefore, in the empirical tests that follow, we do not attempt to disentangle the liquidity effects of these sources and instead focus on the overall impact of these factors. Assuming that portfolio rebalancing speculators pick those positions that could be sold without disrupting the market, we expect the resulting sell-order imbalance to be concentrated in more liquid assets.[6] This decline in liquidity would be moderated by the more widely known 'flight to liquidity' by noise traders and potential capital reallocations by dealers. The net effect of these divergent trade currents on the level and volatility of transaction illiquidity of stocks that are more liquid in the pre-crisis period is difficult to predict. We term this portfolio rebalancing effect the 'flight to liquidity' hypothesis.

Moreover, if the financial stress created by the exogenous shock drives both speculators and dealers out of more volatile (risky) stocks and into relatively less risky stocks (and bonds), it would lead to excessive selling of more risky stocks and a buy-order imbalance in less risky assets. But we expect order imbalance on the sell side (of volatile stocks) to be more severe because the borrowing-constrained speculators use the sales proceeds to meet margin calls (i.e., they *exit* the stock market altogether), rather than to place buy orders for less risky stocks. Moreover, dealers are likely to refocus on low volatility stocks when their capital position deteriorates. These order imbalances in the volatile stocks segment would be exacerbated to the extent noise traders also exit those stocks and move into safe assets. These arguments imply that the increase in liquidity costs and their volatility during the crisis would be more pronounced for risky stocks relative to less risky stocks in the pre-crisis period. We call this type of portfolio shift the 'flight to quality' (or 'safety') hypothesis.[7] A variant of the above two arguments is that during an economic crisis, speculators would exit both the 'more liquid and more risky' segments of the market, leading to an unpredictable change in the market liquidity of those stocks. We call this argument the 'flight to liquidity and quality' hypothesis.

Our final empirical research question is based on arguments that an increase in liquidity costs and liquidity risk raises the required rate of return on securities (*see* Amihud and Mendelson, 1986; Brennan and Subrahmanyam, 1996; Pastor and Stambaugh, 2003; Acharya and Pedersen, 2005; and Liu, 2006). If a financial crisis entails a liquidity shock, then the cross-sectional

6 Bookstaber (2000) notes "the very ability to liquidate—clearly a desirable attribute of an investment portfolio—is, ironically, the root of the liquidity crisis cycle" (p. 20). Kodres and Pritsker (2003) study the role of cross-market hedging of macroeconomic risks in spreading shocks. Their model implies that countries which have more internationally traded financial assets and more liquid markets are likely to be more vulnerable to contagion.

7 For instance, Perold (1999) notes that in normal market conditions, LTCM took a long position in less liquid assets, such as off-the-run US treasury bonds and a short position in relatively more liquid securities like on-the-run T-bonds in many of its trades, thus supplying liquidity to the market. These positions were constructed using extreme leverage. Thus, it provided liquidity by focusing on temporary mispricing of securities due to liquidity-demanding trades by other financial institutions. When global financial markets encountered an exogenous shock, such as the Russian default on government bonds in August 1998, there was a flight to quality and liquidity. LTCM suffered heavy losses on its spread trading strategies. To meet margin calls, it needed to sell its less liquid holdings along with other investors. This stampede dried up liquidity in the less liquid asset markets. Moreover, LTCM needed to buy the more liquid assets in a market under crisis when other investors were running for cover—a general flight to quality. Thus, the leverage-laden investment strategies of hedge funds with huge positions to unload at short notice precipitate/exacerbate a liquidity crisis. While hedge funds provide liquidity during normal times, they consume huge liquidity under financial turmoil.

abnormal returns due to the crisis should in part be negatively related to the innovations in the level and volatility of liquidity costs. We call this the 'liquidity-wealth effects' hypothesis.

Sample Selection and Methodology

Empirical tests of the above research questions require transactions data—micro-level data on trades and quotes, not simply the firm-level data. Unfortunately, we could not find trade-level data on Asian currencies and stocks which constituted the epicenter of the Asian crisis of 1997. As a second best choice, we test the above predictions concerning the interaction between economic crisis and market liquidity using transactions data on the US stocks surrounding the Asian currency crisis.

Following Forbes (2004), we focus on two channels of transmission of a crisis from one country to another, product competitiveness and the income effect. Product competitiveness assumes that exports from countries in the crisis region would become cheaper following currency devaluation. Therefore, firms competing with major exports from the crisis countries would be exposed to the crisis indirectly. Income effect supposes that firms that sell or operate in the crisis country experience a decline in profitability due to lower or negative economic growth rates. These firms are deemed to have direct exposure to the crisis.[8]

Although some economies in Asia, like Indonesia, Malaysia, the Philippines and Thailand, began experiencing problems in early 1997, the literature on the Asian currency crisis indicates that the economic problems of these economies did not have any effect on the US market until June 1997 (*see* Roubini, 1998). Also, the New York Stock Exchange (NYSE) reduced the minimum tick size for quoting and trading stocks from eighth to sixteenth on June 24, 1997. Goldstein and Kavajecz (2000) find that the average quoted spread decreased by 14.3% and average quoted depth decreased by 48.4% following the reduction in minimum tick size. As we notice similar decreases in both spread and depth measures in our sample, we exclude the period prior to July 1997 for our study to avoid potential bias due to the change in minimum tick size. Based on Roubini (1998), Forbes (2004), and Forbes and Rigobon (2002), we select October 17, 1997 to November 1, 1997 as the crisis period and the period over July to September 1997 as our pre-crisis period.[9] Since the July-September time window is contaminated by the initial sporadic minor eruptions of the Asian crisis, we are less likely to

[8] Forbes (2004) is the first study to use firm-level data to examine how the crises are transmitted internationally. Using a sample of over 10,000 companies from 46 countries, she examines whether firms exposed to the East Asian and Russian crises suffer more negative abnormal returns than those unexposed. She discusses the following additional channels through which a crisis in one country could be transmitted to firms in other countries. The third channel is credit crunch under which a crisis in one country results in a reduction in international supply of credit, raising the cost of credit to firms in other countries. The fourth is forced portfolio recomposition, in which investors in a crisis country sell assets in other markets to meet margin, regulation and other requirements, thereby transmitting the crisis to other countries. Finally, a crisis in one country might cause investors to re-evaluate the risk of investing in similar countries and might result in their withdrawing investments from such countries.

[9] Forbes (2004) uses a 12-week crisis period (October 1, 1997 to December 24, 1997). She uses a longer window because her sample covers a large global sample of firms covering many countries which fell victim one after another to the gradually spreading currency crisis. In contrast, our sample consists of only the US companies. Since the US markets are relatively more efficient, we expect that the stock market reaction to the Asian crisis would be much faster and hence a two-week event window is sufficient. To check the robustness of the results presented in this study, we replicate our tests using a 12-week crisis window and find that the results are not significantly different. These revised results are available from the authors on request.

find an increase in trading costs from the pre-crisis to the crisis period. We define the post-Asian crisis period as the time window over November 2, 1997 to July 31, 1998. Beyond July 1998, the US market was exposed to the Russian and LTCM crises.

We select firms that are exposed and not exposed to the Asian crisis from the S&P 500 and S&P 400 Midcap indices and are listed on the NYSE. Crisis exposure is determined in two ways. First, using the Compustat database, we classify firms that have foreign operations and/or significant sales/service offices in the crisis region with sales in excess of 5% of their total annual sales as 'sales-exposed' companies.[10] Given their significant exports to the Asian region, these firms would witness a decrease in sales because of appreciation in the value of the US dollar and the potential economic slowdown in the crisis region. These companies are exposed to the crisis because of the income effect. Our search yielded a total of 84 such sales-exposed companies. After removing 11 companies that do not survive the entire sample period (pre-crisis to post-crisis) and 18 firms undergoing mergers and/or stock splits during the period, we are left with 55 sales-exposed firms.

In addition, we follow Forbes (2004) to select firms exposed to the crisis due to product competitiveness—those with their main product lines in the same industry as the major exports from the crisis region. Major exports for the crisis region are defined as the four-digit SITC (Standard Industrial Trade Classification) group for which total exports from countries in the crisis zone are 20% or more of total exports to the entire world. This gives a rough approximation of the industries that are most likely to be affected by the crisis. Using these SITC and corresponding SIC codes, we select all NYSE-listed US companies having similar SIC codes and call this group the SIC-exposed sample. As the currencies of countries in the crisis region devalue, the SIC-exposed firms have to compete with cheaper exports from the Asian region. We found 60 such SIC-exposed companies. After removing companies that were not present for the whole sample period (19 firms) and those companies associated with mergers and/or stock splits during the period (14 firms), we are left with 27 SIC-exposed companies (of which 8 are also part of the sales-exposed subset). Altogether, our exposed sample includes 74 firms. To construct a sample of firms not exposed to the Asian crisis, we find 617 US incorporated firms that are members of the S&P 500 and S&P 400 Midcap indices and listed on the NYSE. From this set, we remove 236 firms with foreign operations and/or significant sales/service offices in foreign regions (with geographic region code = 20 in Compustat), 64 firms with insufficient data and 114 firms subject to mergers and/or stock splits during the period. This yields an unexposed sample of 203 firms from the S&P 500 and S&P 400 Midcap indices.

Data

We collect daily as well as transactions data from the NYSE Transactions and Quote (TAQ) database on a sample of ordinary equities of companies incorporated in the US over July 1997

[10] Ideally we would like to measure the dollar value of sales for the US firms operating in a specific country in the Asian region. However, many companies report foreign exposure by region, not by country. The country level sales data is not available in the Compustat database for most companies in our sample. Therefore, we measure crisis exposure by taking sales in the Asian region as a percentage of total sales of a firm.

through August 1998. Consistent with past market microstructure studies, we exclude transactions reported out of sequence or after closing, those with special settlement conditions, and the first trade of the day for each stock. Further, we discard negative values of bid-ask spreads, quotations, transaction prices and quoted depths. Following Lee and Ready (1991), any quote less than 5 seconds prior to the trade is ignored and the first one at least 5 seconds prior to the trade is retained. In addition to trading volume (in number of shares and the dollar volume) and average trade size (number of shares), we estimate the following traditional measures of liquidity costs and market depth for each firm during the pre-crisis, crisis and post-crisis periods:

- Quoted Spread : $P_A - P_B$, where P_A = ask price and P_B = bid price
- Proportional Quoted Spread : $(P_A - P_B) / P_M$, where $P_M = (P_A + P_B)/2$
- Quoted Depth : $1/2(Q_A + Q_B)$, where Q_A and Q_B are quoted depths (number of shares) at the ask and bid prices
- Effective Spread : $2|P_t - P_M|$, where P_t = trade price
- Proportional Effective Spread : $2|P_t - P_M| / P_M$

These liquidity measures were winsorized at the 1% and 99% levels. We also measure the second moments of all liquidity measures to assess uncertainty about market liquidity (liquidity risk) during the market crisis.

Univariate Empirical Results

Descriptive Statistics

We begin the empirical analysis by verifying that the Asian crisis did affect the aggregate US equity market. From the first panel of Table 1 we note that the median daily stock returns on

Table 1: Asian Crisis and the US Stock Market (in %)

	Pre-Crisis	Crisis	Post-Crisis
Daily S&P 500 Index Returns			
Mean	0.11	–0.35	0.11
Median	0.21	–0.39	0.11
Std. Dev.	1.06	2.94	0.93
Daily Wilshire 5000 Index Returns			
Mean	0.15	–0.37	0.08
Median	0.24	–0.27	0.18
Std. Dev.	0.87	2.66	0.85
CBOE SPX Market Volatility Index			
Mean	0.20	5.59	–0.04
Median	–0.23	1.69	–0.47
Std. Dev.	4.69	12.15	5.49

the S&P 500 index decrease from 0.21% in the pre-crisis period (July-September, 1997) to –0.39% during the crisis period (October 17-November 1, 1997), while the standard deviation increases from 1.06% to 2.94%. In the next panel, the broader Wilshire 5000 index exhibits similar patterns. In the last panel, we present summary statistics on the daily changes in Volatility Index (VIX) of the Chicago Board Options Exchange. VIX measures market expectation of stock volatility over the next 30 days based on the S&P 500 index option prices. The median daily change in the index jumps from –0.23% in the pre-crisis period to 1.69% during the crisis window, and the standard deviation of daily changes rises sharply from 4.69% to 12.15%. These descriptive statistics clearly show that the Asian crisis was followed by falling returns and increased volatility in the US equity markets.

Table 2 presents the summary statistics of daily trading volume, average trade size and total number of quotes and trades for our sample of 74 exposed and 203 unexposed firms. These summary statistics paint a broad picture of the trading environment surrounding the crisis. While the daily total trading volume across all the exposed and unexposed stocks increases during the crisis and then drops, the average trade size drops dramatically over the crisis window. In Panel B, the total number of trades and quotes (across all days) plummet

Table 2: Descriptive Statistics

Panel A: Trade Data

Time Period	Daily Trading Volume (million shares)		Trade Size (00 shares)	
	Mean	Median	Mean	Median
Exposed Firms (74)				
Pre-Crisis	59	58	703	686
Crisis	69	72	121	110
Post-Crisis	55	54	830	847
Unexposed Firms (203)				
Pre-Crisis	57	57	641	640
Crisis	71	67	109	99
Post-Crisis	61	61	391	372

Panel B: Details of Transaction Data Used

Time Period	Exposed Firms		Unexposed Firms	
	Total No. of Quotes (million)	Total No. of Trades (million)	Total No. of Quotes (million)	Total No. of Trades (million)
Pre-Crisis	2.13	1.46	3.18	1.64
Crisis	0.39	0.29	0.62	0.35
Post-Crisis	5.99	4.11	9.69	5.45
Total	**8.52**	**5.86**	**13.49**	**7.30**

across the board in response to the shock. The last row indicates that our analysis uses a total of over 22 million quotes and 13 million trades.

Univariate Analysis of Crisis-Induced Changes in Market Liquidity

To get a preliminary view of the behavior of trading liquidity of individual stocks under the Asian crisis, we conduct univariate analyses of temporal and cross-sectional changes in several key measures of spread and depth. We compute the daily average quoted relative time-weighted spread for each firm, where the time-weight is equal to the length of time that a quote is valid as a fraction of the time between the first quote and close of the trading day. In addition, we examine effective relative spread, quoted depth and standard deviations of daily spread and depth as measures of liquidity risk. We calculate these measures separately for the crisis, pre-crisis and post-crisis periods. These daily measures are averaged across all firms in each sub-sample for each of the three time periods. The Wilcoxon signed-rank test and a paired *t*-test are used to test the null hypothesis that the liquidity measures remain unchanged over the crisis to pre-crisis, (*p*-values are reported in the pre-crisis row in parentheses), post-crisis to crisis (*p*-values shown in the crisis row in parentheses), and post-crisis to pre-crisis periods (*p*-values are shown in the post-crisis row in parentheses). A related question of interest is whether the changes in spread and depth and their volatilities are temporary or persistent. As the post-crisis window covers seven months, comparisons of the post- to the crisis-period and of the post- to the pre-crisis period shed light on this question. The corresponding proportions of firms exhibiting an increase between the two periods are shown under the columns titled Prop > 1 (Table 3).

From Table 3, the median time-weighted quoted spread increases from 0.406% to 0.455% for the exposed companies and from 0.446% to 0.477% for the unexposed companies over the pre-crisis to crisis window, both highly statistically significant under the Wilcoxon signed-rank tests. On an average, over 75% of the firms in each group exhibit an increase in

Table 3: Impact on Time-Weighted Bid-Ask Spread and Depth

Panel A: Exposed Companies (74)

	Quoted Spread (%)		Effective Spread (%)		Quoted Depth ($ 00)	
Mean		**Prop>1**		**Prop>1**		**Prop>1**
Pre-Crisis	0.407 (0.01)	0.86	0.204 (0.01)	0.88	3854 (0.01)	0.22
Crisis	0.479 (0.09)	0.43	0.257 (0.37)	0.38	3561 (0.39)	0.54
Post-Crisis	0.451 (0.01)	0.71	0.227 (0.34)	0.59	3377 (0.01)	0.35
Median						
Pre-Crisis	0.406 (0.01)	0.84	0.202 (0.01)	0.88	3876 (0.01)	0.28
Crisis	0.455 (0.27)	0.51	0.242 (0.13)	0.38	3579 (0.71)	0.52
Post-Crisis	0.449 (0.01)	0.64	0.226 (0.01)	0.58	3406 (0.01)	0.27

Table 3 (Cont.)

	Quoted Spread (%)		Effective Spread (%)		Quoted Depth ($ 00)	
Std. Dev.		**Prop>1**		**Prop>1**		**Prop>1**
Pre-Crisis	0.032 (0.01)	0.67	0.024 (0.01)	0.77	407 (0.24)	0.21
Crisis	0.079 (0.03)	0.48	0.051 (0.01)	0.35	319 (0.05)	0.78
Post-Crisis	0.043 (0.07)	0.81	0.021 (0.01)	0.69	459 (0.09)	0.49
Panel B: Unexposed Companies (203)						
Mean						
Pre-Crisis	0.443 (0.01)	0.77	0.246 (0.01)	0.75	3169 (0.01)	0.56
Crisis	0.491 (0.01)	0.23	0.271 (0.01)	0.23	2811 (0.17)	0.43
Post-Crisis	0.442 (0.47)	0.48	0.239 (0.03)	0.44	2895 (0.01)	0.43
Median						
Pre-Crisis	0.446 (0.01)	0.75	0.245 (0.01)	0.7	3161 (0.46)	0.6
Crisis	0.477 (0.01)	0.25	0.257 (0.01)	0.26	2881 (0.01)	0.38
Post-Crisis	0.441 (0.65)	0.47	0.236 (0.02)	0.43	2911 (0.01)	0.41
Std. Dev.						
Pre-Crisis	0.031 (0.01)	0.57	0.013 (0.01)	0.68	315 (0.79)	0.47
Crisis	0.056 (0.03)	0.49	0.041 (0.01)	0.42	297 (0.66)	0.59
Post-Crisis	0.035 (0.07)	0.62	0.016 (0.03)	0.61	311 (0.71)	0.63

Panel C: Pair-Wise Correlations Between Liquidity Measures for Exposed and Unexposed Firms

Time Period		Quoted Spread (%)	Effective Spread (%)	Quoted Depth ($)	Quoted Depth (Shares)
Pre-Crisis	Equally-Weighted	0.85	0.35	0.56	0.41
	Value-Weighted	0.79	0.44	0.38	0.27
Crisis	Equally-Weighted	0.79	0.98	0.51	0.22
	Value-Weighted	0.92	0.94	0.28	0.18
Post-Crisis	Equally-Weighted	0.79	0.65	0.69	0.58
	Value-Weighted	0.86	0.75	0.57	0.58

the quoted spread from the pre-crisis to the crisis period. While the median drops following the crisis, the decrease is significant only for the unexposed sub-sample. Further, the long-term increase (from the pre-crisis to the post-crisis period) in the median quoted spread is significant for only the exposed sample. In the next column, we present tests based on the effective spread, which is a better measure of trading costs because it takes into account trades that occur inside the best quotes as well as those struck in the upstairs market. We measure the relative effective spread as twice the absolute value of the difference between transaction price and the prevailing quote midpoint, expressed as a percentage of the quote midpoint. In our sample, the median effective spreads are in the 0.20% to 0.25% range, roughly half the median quoted spreads. Similar to the quoted spread, the effective spread increases sharply in response to the crisis for both exposed and unexposed stocks.

In contrast, the time-weighted quoted depth in dollar terms shows a decline from the pre-crisis to the crisis period. The median depth decreases from $387,600 to $357,900 for the exposed and from $316,100 to $288,100 for the unexposed firms. The decrease in median depth is statistically significant only for the exposed companies. On average, about 72% of the exposed and 40% of the unexposed firms exhibit a decrease in median market depth. We interpret the significant increase in both spread measures accompanied by a significant decrease in dollar market depth from the pre-crisis to the crisis period for the exposed firms as a strong indication of a liquidity crunch during the Asian crisis. The concurrent increase in spreads and decrease in depth for the 'unexposed' companies provide strong evidence of contagion in market liquidity during the crisis. Moreover, we often find a significant increase (decrease) in median spreads (depth) from the pre-crisis to the nine-month long post-crisis window for all stocks, indicating a long-term drop in market liquidity following the Asian crisis.

We also estimate the cross-sectional (equally-weighted) averages of daily spread and depth measures for each sub-period for the exposed and unexposed samples and perform the (median-based) Levene test for homogeneity of variances across the three time windows. The results show a significant increase in the volatility (standard deviation) of quoted spreads during the crisis period for both the groups. For instance, the standard deviation of daily quoted spreads surges from 0.032% to 0.079% for the exposed group, and 0.031% to 0.056% for the unexposed group. This indicates a dramatic increase in liquidity risk (i.e., greater uncertainty about trading costs) during the crisis period. Further, we notice that while there is a drop in the standard deviation of spreads from the crisis to the post-crisis period, there is evidence of a significant increase in volatility from the pre- to the post-crisis period. In contrast, the change in the volatility of depth tends to be insignificant. The decreased mean depth along with little change in its volatility during the crisis window reflects market makers' unwillingness to commit capital to take inventory positions during the crisis.[11]

[11] To make sure that the above results on market liquidity are not driven by the significant drop in stock price alone, we also computed spread measures as cents per share and depth measured in number of shares (round lots). The mean quoted (effective) spread increases from $0.131 to $0.17 ($0.084 to $0.098) for the exposed group from the pre- to the crisis-period and the corresponding mean for the unexposed sample are $0.133 to $0.151 ($0.087 to $0.099). Similarly, the average depth in shares drops during the crisis. These changes are highly significant for both exposed and unexposed firms, but the drop in depth is significant only for the unexposed group. Additionally, there is a dramatic drop in median trade size from 686 to 110 round lots and from 640 to 99 round lots for the two groups, respectively. Finally, the volatilities of spreads increase while those of depth and trade size drop sharply.

Another general question of interest is the potentially contagious effects of the crisis, as reflected by correlations, on market liquidity between the exposed and unexposed samples. To explore this issue, we compute pair-wise correlations in the spread and depth measures over the three crisis-related time windows. For each sub-sample, we use equal-weighted and value-weighted (based on the market capitalization as of the beginning date of each time window) cross-sectional averages of daily liquidity measures to capture both the breadth and depth of the crisis effects. Compared to the equal-weighted measures, the value-weighted correlations are dominated by the liquidity of large-cap stocks. The results in Panel C show that value-weighted correlations in both spread measures increase from the pre-crisis period to the crisis period and the increase is dramatic for the effective spread. This is followed by a drop in correlations in the post-crisis period. In contrast, both types of correlations in the two depth variables show a decline, followed by a marked increase following the crisis. It is worth noting that these unadjusted correlations are biased due to heteroskedasticity and endogeneity (*see* Forbes and Rigobon, 2002).

Overall, we find that while the exposed firms suffer a price drop on average during the Asian crisis, the unexposed firms witness an increase in price. Yet, both groups of stocks typically experience a persistent deterioration in trading liquidity, marked by significant increases in spreads, volatility of spreads, co-movement in spreads between the exposed and unexposed stocks, decrease in depth and depth correlations. These preliminary univariate results provide strong support for our liquidity crunch and contagion hypotheses.

Multivariate Analysis of Changes in Market Liquidity

Models of financial crises and market microstructure address how investors and market makers respond to the wealth shocks and return volatility spikes accompanying a turmoil and the corresponding effects on the level, volatility and co-movement of transaction liquidity. We begin the investigation of these linkages with a structural multivariate analysis of changes in the level of spread and depth during the crisis and follow it up with an analysis of changes in the variability of liquidity.

To investigate innovations in the levels of spread and depth, we perform a pooled time series cross-sectional multivariate analysis of quoted spread and depth. Following Demsetz (1968), Stoll (1978) and Copeland and Galai (1983), we regress spread and depth on the level of stock price, trading volume, and volatility of stock returns, using variants of the following log-linear specification:

$$\begin{aligned} lnLiquidity_{jt} = \; & \beta_0 + \beta_1 lnPrice_{jt} + \beta_2 lnVolume_{jt} + \beta_3 lnVolatility_{jt} + \delta_1 CRISIS_t \\ & + \delta_2 POSTCRISIS + \delta_3 lnPrice_{jt} * CRISIS_t + \delta_4 lnVolume_{jt} * CRISIS_t \\ & + \delta_5 lnVolatility_{jt} * CRISIS_t + \delta_6 LIQ_j * CRISIS_t + \delta_7 QUAL_j * CRISIS_t \\ & + \delta_8 LIQUAL_j * CRISIS_t + \varepsilon_{jt} \qquad \ldots(1) \end{aligned}$$

We use daily data over July 1997 through July 1998 (262 days) across 277 firms (74 directly exposed and 203 unexposed). The dependent variable, $lnLiquidity_{jt}$, represents the natural log of either daily average relative effective spread[12] (*lnEffsprd*)or daily time-weighted average dollar depth based on transactions data for each stock (*lnDepth*). The common explanatory variables, $lnVolume_{jt}$, $lnPrice_{jt}$, and $lnVolatility_{jt}$, represent natural logs of daily trading volume (in shares), closing stock price, and volatility of returns (standard deviation of changes in intraday mid-point price quotes), respectively. To evaluate the liquidity crunch hypothesis (temporal effects), we add two dummy variables to isolate the effects of the Asian crisis: *CRISIS,* which takes a value of one for the crisis period (October 17 through November 1, 1997) and 0 otherwise, and *POSTCRISIS,* which equals 1 for the post-crisis time period (November 2, 1997 through July 31, 1998) and 0 otherwise. Further, we interact the *CRISIS* test variable with the three explanatory variables to assess the change in the marginal effects of the fundamental determinants of liquidity during the crisis. To examine the liquidity contagion hypothesis (cross-sectional effects), we perform separate regressions on the exposed and unexposed sub-samples.[13] Given the perfect clustering of observations in our sample, the OLS estimates are not consistent or efficient because the error terms are not homoskedastic, independent and identically distributed in the cross section. Following Beck and Katz (1995), we use the Panel Corrected Standard Errors (PCSE) procedure to estimate pooled time series cross-sectional regressions that correct for heteroskedasticity and first order autocorrelation.

Previous empirical work in market microstructure shows that spread is decreasing in average share price ($\beta_1 < 0$) and trading volume ($\beta_2 < 0$) but increasing in volatility of returns ($\beta_3 > 0$). The opposite holds for market depth. Our liquidity crunch hypothesis predicts that trading costs (market depth) would increase (decrease) during the crisis period, implying that the estimate of the *CRISIS* coefficient, δ_1, would be positive for spread and negative for depth. In addition to the increase in the intercept, it is of interest to check if dealers price the three common determinants of liquidity differently across the exposed and unexposed stocks when the market is in turmoil. We test for such slope changes by interacting the binary *CRISIS* with the three widely-used determinants of spread and depth, $lnVolume_{jt}$, $lnPrice_{jt}$ and $lnVolatility_{jt}$.

Entries in the last row of Panels A and B of Table 4 indicate that the regressions explain about 95% of cross-sectional and time series variations in spread and depth. Consistent with the previous market microstructure studies, the coefficient estimate for each control variable ($lnVolume_{jt}$, $lnPrice_{jt}$ and $lnVolatility_{jt}$) has the predicted sign and is highly significant in all spread and depth regressions. Column 2 of Panels A and B presents estimates for the exposed sub-sample. The coefficient estimate for the *CRISIS* dummy shows that the mean effective spread for exposed stocks increases by 0.059%, but the drop in market depth is insignificant during the Asian crisis after controlling for $lnVolume_{jt}$, $lnPrice_{jt}$ and $lnVolatility_{jt}$. The coefficient estimates for the *POSTCRISIS* dummy suggest that while the mean effective spread decreases

[12] We also used the natural logarithm of time-weighted daily average quoted proportional spread as a dependent variable. The results were qualitatively similar.

[13] Since we do not have information on the precise magnitude of a firm's exposure to the Asian crisis, we are constrained to run separate regressions for the two groups of stocks. An added econometric advantage of running separate regressions is that they are less exposed to the potential collinearity problems associated with the alternative specification based on an indicator variable to distinguish between the exposed and unexposed stocks.

Table 4: Multivariate Analysis of the Effects of the Asian Crisis on Stock Market Liquidity

Panel A: Effective Spread						
Independent Variables	*lnEffsprd*					
	Exposed Firms		**Unexposed Firms**		**Joint Sample**	
Controls						
Intercept	–0.739 (0.01)	–0.743 (0.01)	–0.641 (0.01)	–0.639 (0.01)	–0.679 (0.01)	–0.663 (0.01)
lnPrice	–0.907 (0.01)	–0.906 (0.01)	–0.898 (0.01)	–0.898 (0.01)	–0.901 (0.01)	–0.901 (0.01)
lnVolume	–0.047 (0.01)	–0.049 (0.01)	–0.053 (0.01)	–0.054 (0.01)	–0.051 (0.01)	–0.051 (0.01)
lnVolatility	0.429 (0.01)	0.425 (0.01)	0.445 (0.01)	0.445 (0.01)	0.441 (0.01)	0.443 (0.01)
Tests						
Liquidity Crunch and Contagion						
CRISIS	0.059 (0.01)		0.032 (0.01)			
POSTCRISIS	–0.012 (0.04)	–0.013 (0.03)	–0.017 (0.04)	–0.017 (0.04)	–0.017 (0.01)	–0.021 (0.01)
*lnPrice*CRISIS*		–0.001 (0.96)		–0.007 (0.57)		
*lnVolume*CRISIS*		0.026 (0.01)		–0.005 (0.25)		
*lnVolatility*CRISIS*		0.081 (0.01)		0.001 (0.98)		
Flight to Liquidity and Quality						
*LIQ*CRISIS*					–0.009 (0.41)	
*QUAL*CRISIS*					0.071 (0.01)	
*LIQUAL*CRISIS*						0.027 (0.03)
R^2	0.96	0.96	0.97	0.97	0.97	0.97
Firm-Days	19,388		53,186		72,574	

Table 4 (Cont.)

Panel B: Depth						
Independent Variables	*lnDepth*					
	Exposed Firms		Unexposed Firms		Joint Sample	
Controls						
Intercept	4.075 (0.01)	4.066 (0.01)	4.335 (0.01)	4.325 (0.01)	4.245 (0.01)	4.231 (0.01)
lnPrice	0.639 (0.01)	0.641 (0.01)	0.562 (0.01)	0.562 (0.01)	0.593 (0.01)	0.593 (0.01)
lnVolume	0.326 (0.01)	0.325 (0.01)	0.331 (0.01)	0.329 (0.01)	0.328 (0.01)	0.328 (0.01)
lnVolatility	–0.595 (0.01)	–0.601 (0.01)	–0.603 (0.01)	–0.612 (0.01)	–0.601 (0.01)	–0.603 (0.01)
Tests						
Liquidity Crunch and Contagion						
CRISIS	–0.056 (0.14)		–0.068 (0.04)			
POSTCRISIS	–0.053 (0.01)	–0.051 (0.01)	–0.071 (0.01)	–0.069 (0.01)	–0.065 (0.01)	–0.058 (0.01)
*lnPrice*CRISIS*		–0.001 (0.99)		0.013 (0.65)		
*lnVolume*CRISIS*		0.019 (0.20)		0.033 (0.01)		
*lnVolatility*CRISIS*		0.086 (0.03)		0.156 (0.01)		
Flight to Liquidity and Quality						
*LIQ*CRISIS*					–0.0215 (0.40)	
*QUAL*CRISIS*					–0.073 (0.02)	
*LIQUAL*CRISIS*						–0.033 (0.31)
R^2	0.94	0.94	0.94	0.94	0.94	0.94
Firm-Days	19,388		53,186		72,574	

by 0.012% during the 9-month-long post-crisis period, the mean depth decreases by 0.056%. Together, these two estimates imply an ambiguous net effect on market liquidity over the entire sample period. However, as we point out later, these persistent effects appear to be biased downward by the expansionary monetary policy of the Federal Reserve Bank (Fed).

Further, we conduct tests to check if the dramatic increase in the demand for liquidity coupled with a reduction in the supply of liquidity due to dealer capital constraints during the crisis alters the three slope coefficients. In our sample, performing a joint test of the intercept and slope changes is beset with econometric problems because of extremely high degrees of collinearity between *CRISIS* and its interactions with $lnVolume_{jt}$, $lnPrice_{jt}$ and $lnVolatility_{jt}$.[14] Therefore, we drop the *CRISIS* binary variable and introduce just its interactions with the three spread determinants in column 3. The estimate on *lnVolume**CRISIS* is 0.026 in the spread regression, implying that for a 1% increase in trading activity, market makers lower the mean quoted spread by only 0.023% (= 0.049 – 0.026) during the crisis as opposed to 0.049% during the pre-crisis period. Further, they refrain from increasing depth on average as suggested by the insignificant coefficient on this interaction variable in the depth regression. We infer from these two interaction coefficients that despite a sudden increase in average trading activity during the crisis (see Table 2), dealers tend to price the order flow more aggressively (i.e., reduce the spread by a smaller percentage relative to normal market conditions). This behavior seems rational because the observed increase in average trading volume is likely to be primarily due to a significant increase in order imbalances during the crisis. In contrast, the results with respect to *lnVolatility**CRISIS* are mixed. While the estimate of 0.081 in the spread regression suggests that the marginal effect of return volatility on liquidity increases significantly in turbulent market conditions, the corresponding estimate of 0.086 in Panel B implies that market makers increase depth on average at the same time. Together, the above estimates on the three interaction variables suggest that increased trading volume (reflecting order imbalance) is the primary contributor to higher trading costs of stocks directly exposed to the Asian crisis.

Moving on to the unexposed sub-sample in column 4, the mean effective spread increases by 0.032%, while the average depth drops by 0.068% during the Asian crisis. Together, they provide strong support to our 'liquidity contagion hypothesis', which predicts a liquidity spillover as speculative traders sell off both exposed and unexposed stocks and dealers curtail supply of immediacy during market turmoil. Following the crisis, both average spread and depth decline by 0.017% and 0.071%, respectively, indicating again mixed (but potentially downward biased) results over the entire sample period. The added results in column 5 show little change in the three slope coefficients in the spread equation (see the interaction variables), but those associated with volume and volatility in the depth regression are significant during the crisis. Comparing the estimates between the two groups of stocks, in Panel A we notice a sharper increase in spread for the exposed firms during the crisis, in terms of the increase in average spread (intercept change) as well as the increased sensitivities (slope changes) of the spread to volume and volatility. But the changes in mean depth and

[14] Pair-wise correlations between CRISIS and its interactions with $lnVolume_{jt}$, $lnPrice_{jt}$ and $lnVolatility_{jt}$ are around 0.99 and thus obscure their marginal effects in a joint test.

the sensitivities to order flow and volatility in Panel B are somewhat stronger for the unexposed group. Altogether, we find strong evidence that liquidity deteriorates for both the exposed and unexposed stocks during the Asian flu, but the evidence on the long-term liquidity effects of the economic shock is less clear-cut.

To get a sense of the economic significance of changes in market liquidity, recall from Table 2 that the average daily trading volume during the Asian crisis is 69 (71) million shares for 74 exposed (203 unexposed) stocks. For the exposed group (see foot note 11), the average quoted (effective) spread increases from \$0.131 (\$0.084) in the pre-crisis period to \$0.171 (\$0.098) during the crisis window. The corresponding mean increase for the unexposed firms is from \$0.133 (\$0.087) to \$0.151 (\$0.099). This implies that investors in the exposed stocks faced an (unconditional) aggregate increase of \$2.76 (\$0.966) mn in the average quoted (effective) spread per day. Comparable figures for the unexposed stocks are \$1.278 (\$0.852) mn. Based on the conditional estimates of the *CRISIS* coefficients in Table 4, the aggregate increases in the effective spread per day during the crisis are \$1.849 mn and \$0.980 mn, respectively, for the exposed and unexposed samples. These estimates appear to be conservative because they ignore the slope-changes discussed above, the significant decline in market depth, and negative price impact of disposing of block trade in market turmoil. Moreover, the dramatic increase in the variability of spreads (discussed below) suggests that the investor would have faced a great deal of uncertainty about these execution costs.

To conduct tests for the 'flight' hypotheses, we add three dummy variables to the above regression specification. The 'flight to liquidity' hypothesis posits that noise traders rush to liquid stocks and dealers reshuffle their supply function in favor of these stocks, while leveraged investors would liquidate the relatively 'more liquid' positions to meet margin calls. To assess the net effect of these trade cross-currents, we construct a dummy variable, LIQ_j, which takes a value equal to 1 if firm *j* is more liquid (below-median effective spread or above-median dollar depth) in the pre-crisis period. We interact this dummy variable with *CRISIS.* Since the net effect of the flight to liquidity is difficult to predict, the sign on the interaction coefficients (δ_6) is an empirical issue**.** The dummy variable $QUAL_j$ equals one for more volatile firms as measured by above-median pre-crisis return volatility. The 'flight to quality' hypothesis posits that market makers, speculators and noise traders would flee from more risky stocks to less risky stocks and bonds. This would likely cause greater order imbalance for the more risky stocks, implying a positive sign for δ_7 'in the spread regression'. The dummy variable $LIQUAL_j$ equals one if the firm has both above-median liquidity *and* above-median risk in the pre-crisis period. Under the 'flight to liquidity and quality' hypothesis, portfolio rebalancing trades in a crisis would be concentrated in more liquid and more risky stocks, but the sign on δ_8 is unknown.

The above hypotheses examine if the liquidity effects of the crisis are concentrated in relatively more liquid or more risky, or both more liquid and more risky stocks in our sample. Having already documented the pervasive liquidity effects of the crisis across both exposed and unexposed stocks, now we combine the two sub-samples to investigate if their loss of liquidity varies with their pre-crisis levels of liquidity and risk. To minimize the problem of multicollinearity, we present estimates for the first two flight tests separately from those of the third flight test. From column 6 of both Panels A and B, the coefficients on *LIQ*CRISIS* are insignificant, implying that the liquidity effect of the crisis on the previously (relatively more) liquid stocks is negligible. In other words, liquid US stocks in our sample appear to have had sufficient liquidity to absorb order imbalances generated by the Asian crisis. However, the coefficients on *QUAL*CRISIS* suggests that the mean spread on stocks that are more risky prior to the crisis increases by 0.071%, whereas the average depth declines by 0.073% during the crisis relative to their less risky counterparts. This evidence is further confirmed by the 0.027% increase in the mean relative effective spread of stocks that are both more risky and more liquid prior to the economic shock (see the coefficient on *LIQUAL*CRISIS* in the next column).

To evaluate the effects of the crisis on the second moment of trading liquidity, we estimate the following regression:

$$lnLiqRisk_{jt} = \beta_0 + \beta_1 lnVolumeVol_{jt} + \beta_2 lnVolatility_{jt} + \delta_1 CRISIS_t + \delta_2 POSTCRISIS_t + \delta_3 LIQ_j{*}CRISIS_t + \delta_4 QUAL_j{*}CRISIS_t + \delta_5 LIQUAL_j{*}CRISIS_t + \varepsilon_{jt} \quad \ldots(2)$$

$LiqRisk_{jt}$ represents either the absolute value of daily change in the relative effective spread or of the daily percentage change in time-weighted dollar market depth. Since most of the coefficient estimates on the test variables are insignificant, we suppress the analysis of changes in the variability of depth to conserve space. $VolumeVol_{jt}$ denotes the absolute value of daily percentage change in trading volume in shares, and $Volatility_{jt}$ represents, as before, return volatility (standard deviation of changes in intraday mid-point price quotes). As expected, both the volatility of trading volume and stock returns are significantly positively related to the daily variability of spread in all specifications presented in Table 5. Our estimates suggest that a change of 1% in the variability of daily returns is associated with 0.547% change in the variability of spread for the exposed group and a slightly lower 0.495% change for the unexposed stocks. From columns 2 and 3, the *CRISIS* coefficient is positive and significant for both groups. With respect to the persistent effect, the *POSTCRISIS* coefficient is not significant for the exposed group, but it is negative and significant for the unexposed sample. These findings suggest a sustained crisis-induced increase in uncertainty about liquidity costs, particularly for the exposed stocks, and provide further support to our 'liquidity crunch and contagion hypotheses'. The liquidity risk results with respect to the flight hypotheses are shown in the last two columns. From column 4, we notice that for the more liquid stocks in the overall sample (see the coefficients on *LIQ*CRISIS*), the variability of spread drops during the crisis, but it registers a strong increase for the more risky stocks (see the coefficient on *QUAL*CRISIS)*. For the smaller sub-set of both more liquid and more risky stocks, the variability of spread drops during the crisis (see the coefficient on *LIQUAL*CRISIS* in the last column). Moreover, in untabulated results, we find that the corresponding *CRISIS*-related coefficients for the volatility of market depth are all typically insignificant. Overall, we find evidence of a significant increase in the variability of liquidity costs during the crisis for both exposed and unexposed stocks. However, the liquidity risk effects are heterogeneous. While the increase in liquidity risk appears to be persistent for the exposed stocks, it is transient for

Table 5: Liquidity Risk				
Independent Variables	*lnLiqRisk*			
Controls	**Exposed**	**Unexposed**	**Joint Sample**	
Intercept	–6.289 (0.01)	–6.345 (0.01)	–6.337 (0.01)	–6.289 (0.01)
lnVolumeVol	0.063 (0.01)	0.038 (0.01)	0.044 (0.01)	0.044 (0.01)
lnVolatility	0.547 (0.01)	0.495 (0.01)	0.503 (0.01)	0.514 (0.01)
Tests				
Liquidity Crunch and Contagion				
CRISIS	0.132 (0.06)	0.101 (0.03)		
POSTCRISIS	0.003 (0.93)	–0.092 (0.01)	–0.082 (0.01)	–0.092 (0.01)
Flight to Liquidity and Quality				
*LIQ*CRISIS*			–0.357 (0.02)	
*QUAL*CRISIS*			0.381 (0.01)	
*LIQUAL*CRISIS*				–0.192 (0.06)
R^2	0.58	0.59	0.59	0.59
Panel = *N*T*	74*260	203*260	277*260	277*260

the unexposed group. Moreover, the liquidity risk increases for more volatile stocks, but it declines for more liquid stocks.[15]

An alternative explanation for the across-the-board decline in market liquidity noted above is a systemic or common influence, such as a change in the monetary policy of the Fed during market turbulence, which can affect liquidity by altering the terms of credit to speculators and dealers. For instance, if the Fed were to adopt an expansionary monetary policy during the Asian crisis, it would tend to increase market liquidity and thus moderate the liquidity crunch and contagion effects of the economic shock. To scrutinize this confounding effect, we analyzed federal fund rates, repurchase rates and call money rates and found them to be essentially constant around the crisis period. Further, following Chordia *et al.* (2005), we examined changes in the net borrowed reserves divided by total reserves of banks, where net borrowed reserves are defined as total borrowings minus extended credit minus excess reserves. In untabulated results, we find that the net borrowed reserves declined significantly from the pre-crisis to the crisis period. This suggests that the Fed loosened the monetary policy during the Asian crisis. But the observed net declines in spread and depth suggest that the negative crisis-induced portfolio rebalancing effects dominate the favorable effects of expansionary monetary policy during the Asian crisis. Moreover, we observe a

[15] A caveat in interpreting these results is that in the wake of an uncertain downward price, spiral dealers withdraw from market-making in less liquid and more risky stocks and limit their activities to more liquid and less risky stocks. This suggests that the observed price, volume and liquidity data during the market crisis are less reliable for the less liquid and more risky stocks and fail to capture the full extent of the loss of true (but unknown) market liquidity.

significant drop in net borrowed reserves from the pre-crisis to the post-crisis period. This suggests that the previously noted simultaneous declines in both spread and depth following the crisis are biased by the easier monetary stance of the Fed.

To sum up, consistent with our 'liquidity crunch and contagion hypotheses', we find evidence of a significant deterioration in the level and volatility of effective spread during the Asian crisis across both exposed and unexposed stocks after controlling for the common determinants of transaction liquidity. However, the evidence on a persistent decline in market liquidity over the post-crisis period appears clouded because the decrease in spread is accompanied by a drop in market depth. Finally, the evidence with respect to our flight hypotheses suggests that the loss of liquidity during the crisis is heterogeneous. While stocks that were more liquid in the pre-crisis period survive the crisis essentially unscathed, their more risky counterparts suffer a steeper loss of liquidity.[16]

Liquidity Shocks and Abnormal Returns

As reviewed earlier, models of crisis and contagion show that the wealth effects comprise three types of ripple price effects. The first is the expected initial drop in exposed asset prices due to the negative shock. The second is the portfolio rebalancing effect due to borrowing or collateral constraints or risk aversion, which could further decrease asset prices. The third price effect is due to the loss of market liquidity, which emerges from order imbalance due to portfolio rebalancing. Recent models in market microstructure predict that the sudden decrease in market liquidity would further reduce asset prices. Recent contagion and liquidity-augmented asset pricing models predict that the endogenous loss of trading liquidity would lead to a price spiral. In this section, we perform tests of the 'liquidity-wealth effects hypothesis' by relating crisis period abnormal returns to the concurrent innovations in liquidity.

We use Cumulative Abnormal Returns (CAR) over the 10-day (October 17 through November 1, 1997) crisis event window as our measure of wealth effects associated with the Asian crisis. To estimate CAR, we construct two equally-weighted portfolios of the exposed and unexposed stocks and estimate parameters of the market model by regressing daily returns for each portfolio against the Center for Research in Security Prices (CRSP) value-weighted market returns over the pre-crisis period (July-September 1997). Following the standard event study methodology, the expected daily portfolio returns for each portfolio over the crisis period are derived and then subtracted from the corresponding actual returns to get the daily abnormal returns and CAR. In testing the null hypothesis that the crisis period CAR are equal to zero for each portfolio, we use the standardized abnormal return test, called Z-statistic, due to Patell (1976). In untabulated results, we notice that both exposed and unexposed firms suffer significant mean negative cumulative abnormal returns of 5.07% and 2.12%, respectively.

[16] To recognize that dealers set spread and depth jointly, we replicate the tests in Table 4 by using the ratio of spread to depth as the dependent variable. The results are qualitatively similar to those reported in Table 4.

Multivariate Analysis of Abnormal Returns

Next we conduct cross-sectional tests to investigate if firms exposed to greater loss of market liquidity during the economic crisis also suffer more negative abnormal returns (market model CAR) after controlling for (pre-crisis) firm size. As noted earlier, it is helpful to think about three sources of price decline during a crisis: the negative public information shock (the 'shock effect'), an increase in bid-ask spreads (the 'spread effect'), and an increase in liquidity or information-disadvantaged premium demanded by uninformed traders (the direct 'price impact'). The 'price impact and spread effects' are attributable to market liquidity. Facing a cascade of sell orders, market makers are likely to not only widen the spread but also move the location of the spread further down the price ladder to guard against informed selling as well as to encourage more public buy orders. Moreover, some dealers would even cease market making operations and demand liquidity to cope with capital constraints. For a simple illustration, suppose the current quotes for a stock are $11 bid and $11.10 ask, and they plummet to $10 bid and $10.15 ask in response to the negative shock. If a dealer is flooded with sell orders at $10 following the shock, she might not only widen the spread to say $0.20, but also move the location of the spread down to $9.50 bid and $9.70 ask. In this example, the 'shock effect' is approximately –$0.97 (equal to the difference between the two mid quotes –$11.05 and $10.08), the direct 'price impact' of the sell order imbalance is roughly –$0.48 (equal to the difference between the two mid quotes, $10.08 and $9.60), and the 'spread effect' is $0.10 (increase from the pre-shock to the post-shock spread). Such sharp drops in quotes and market prices in response to a shock are likely to persist in the short run because of the lack of arbitrage capital due to borrowing constraints faced by informed traders (*see* Yuan, 2004). This example implies that in a crisis, only a small fraction of the price drop that is not related to the negative shock effect may be due to an increase in the observed spreads—the conventional measure of liquidity. In extreme cases of rapidly declining prices, dealers and speculative traders/hedge funds may opt to stand on the sidelines, take a 'wait and see' approach and refuse to commit capital to take contrarian positions to supply liquidity in spite of large apparent arbitrage opportunities.[17] We turn next to an examination of the role of the conventional measures of market liquidity in the Asian crisis.

In models of economic crisis and contagion, the crisis in market liquidity is endogenous and is caused by the initial negative information shock. In some models, the initial increase in liquidity costs due to portfolio rebalancing (induced by borrowing constraints or increased risk aversion) leads to a cascade of further price declines, asset liquidations, and increases in liquidity costs. These dynamics imply a simultaneous relation between CAR and market liquidity. Given this feedback between abnormal returns and the measures of liquidity costs, we use the following simultaneous equations framework to investigate the feedback effects of increase in liquidity costs on abnormal returns:

[17] Bookstaber (2000, p. 22) observes, "The role of liquidity in market crises has not been widely studied. One reason is that the role is difficult to investigate empirically. The liquidity that matters for a crisis is not the same as the liquidity that lies behind bid-ask spreads; it is not a phenomenon that can be readily observed. Market and economic information is widely available, but liquidity demand and supply are locked within the preferences and capital constraints of each trader."

$$CAR_i = \alpha_0 + \alpha_1 lnEffsprdratio_i + \alpha_2 lnDepthratio_i + \alpha_3 lnSize + \alpha_4 lnLrratio_i + \varepsilon_{1i} \quad ...(5)$$

$$lnEffsprdratio_i = \beta_0 + \beta_1 lnVolatilityratio_i + \beta_2 CAR_i + \beta_3 lnVolumeratio_i + \beta_4 lnPriceratio_i + \varepsilon_{2i} \quad ...(6)$$

CAR are taken from the market model. The three test variables are: *lnEffsprdratio* denoting natural logarithm of the ratio of crisis to pre-crisis quoted relative effective spreads, *lnDepthratio* representing natural logarithm of the ratio of crisis to pre-crisis time-weighted quoted dollar depth, and *lnLrratio* measured as the natural logarithm of the ratio of crisis period standard deviation to the pre-crisis standard deviation of the relative effective spread.[18] The first two assess the percentage change in the level of spread and depth, while the third captures the percentage change in liquidity risk. In the first equation, *lnSize* is the natural logarithm of pre-crisis firm size (measured as the sum of market value of equity and long-term debt). It is used to control for potential firm size effects on CAR, although its high correlation with the three liquidity innovations tends to weaken the effects of those variables (*see* Acharya and Pedersen, 2005 and Liu, 2006). The choice of regressors in Equation (5) is based on the typical specification used in market microstructure studies (see Equation (1)). *LnVolatilityratio* is the natural logarithm of the ratio of crisis to pre-crisis standard deviations of daily quote mid-points. It is meant to account for changes in total risk due to the economic shock. *LnVolumeratio* and *lnPriceratio* represent ratios of crisis to pre-crisis average trading volume and stock price. If trading liquidity costs and risk are priced factors, our CAPM CAR should include a liquidity premium component and correlate negatively with liquidity innovations, *lnEffsprdratio*, *lnDepthratio* and *lnLrratio.* The results of this regression are reported in Table 6. To minimize potential multicollinearity problems, we introduce *lnLrratio* separately into the abnormal returns regressions.

In the first regression in Panel A, the coefficient estimate for *lnEffsprdratio* is significantly negative for the exposed sample. Consistent with our predictions, this estimate indicates that a one percent increase in effective spreads is associated with a 0.227% decrease in cumulative abnormal returns during the crisis period. But when we add both sources of liquidity innovations to the regression, the estimate on the *lnLrratio* is surprisingly positive and significant (also Chordia *et al.,* 2001). The estimate on the *lnDepthratio* is insignificant in both regressions. Apparently, high collinearity among the four regressors complicates the task of distinguishing statistically the relative importance of the liquidity factor. Further, the intercept estimates are insignificant, implying that the liquidity innovations coupled with firm size offer a satisfactory explanation of the abnormal returns. In Panel B, both *lnEffsprdratio* and *lnLrratio* are negatively associated with CAR for the unexposed firms. One percent increase in the level of spread and its volatility is, at the margin, associated with drops of 0.031 and 0.018 percents, respectively. Clearly, the negative liquidity effects on abnormal returns appear to be more muted. The estimates on the control variables are broadly consistent

[18] In our sample, the ratios of standard deviations of spread and depth are highly correlated with the ratios of the average levels of these variables. To minimize potential multicollinearity problems, we use only the ratio of standard deviations of spread as a test variable.

Table 6: Cumulative Abnormal Returns and Market Liquidity: Three-Stage Least Squares Estimates

Panel A: Exposed Firms (72)									
(i)	**Intercept**	***lnEffsprd-ratio***	***lnDepth-ratio***	***lnSize***	***lnLrratio***	***lnVolatility-ratio***	**CAR**	***lnVolume-ratio***	***lnPrice-ratio***
CAR	–0.074	–0.227	0.012	0.011					
	(0.10)	(0.01)	(0.63)	(0.06)					
Adj. R^2	0.01								
lnEffsprdratio	0.055					0.509	–0.338	–0.018	–0.786
	(0.01)					(0.01)	(0.57)	(0.49)	(0.01)
Adj. R^2	0.57								
(ii)									
CAR	–0.048	–0.266	–0.007	0.005	0.04				
	(0.31)	(0.01)	(0.79)	(0.36)	(0.03)				
Adj. R^2	0.04								
lnEffsprdratio	0.064					0.666	0.634	–0.031	–0.958
	(0.01)					(0.01)	(0.25)	(0.31)	(0.01)
Adj. R^2	0.61								
Panel B: Unexposed Firms (201)									
(i)	**Intercept**	***lnEffsprd-ratio***	***lnDepth-ratio***	***lnSize***	***lnLrratio***	***lnVolatility-ratio***	**CAR**	***lnVolume-ratio***	***lnPrice-ratio***
CAR	–0.109	–0.064	–0.012	0.013					
	(0.01)	(0.07)	(0.32)	(0.01)					
Adj. R^2	0.14								

Table 6 (Cont.)

Panel B: Unexposed Firms (201)									
(i)	**Intercept**	***lnEffsprd-ratio***	***lnDepth-ratio***	***lnSize***	***lnLrratio***	***lnVolatility-ratio***	**CAR**	***lnVolume-ratio***	***lnPrice-ratio***
lnEffsprdratio	0.028					0.478	–0.243	–0.036	–0.937
	(0.01)					(0.01)	(0.51)	(0.02)	(0.01)
Adj. R^2	0.58								
(ii)									
CAR	–0.116	–0.031	–0.007	0.014	–0.018				
	(0.01)	(0.46)	(0.52)	(0.01)	(0.06)				
Adj. R^2	0.13								
lnEffsprdratio	0.023					0.47	–0.585	–0.034	–0.929
	(0.03)					(0.01)	(0.11)	(0.03)	(0.01)
Adj. R^2	0.56								

with the findings of past studies. Thus, the three-stage least squares estimates strongly support our 'liquidity-wealth effects' hypothesis which posits that the negative *CARs* for both exposed and unexposed firms are in part due to the loss of market liquidity in an economic crisis.

Earlier we noted that in response to a cascade of expected price drops, market makers would (a) either lower the location of the bid-ask spread or (b) widen the spread or (c) both. The significant but small explanatory power of the change in the level of effective spread and its volatility in the cross-sectional regressions reported in Table 6 suggests that in a crisis the liquidity premium (i.e., 'direct price impact') in the form of a price decline noted in (a) dominates the conventional liquidity effects (measured by spread level, its uncertainty and depth). In contrast, in normal markets, dealers increase the bid-ask spread to cope with a sell-order imbalance and induce investor buy-orders to balance their inventories, without necessarily lowering the location of spread. To the extent this selling pressure-driven price drop is excessive (i.e., not related to the negative information shock but due to the lack of market liquidity), we should expect a price reversal in the post-crisis window.

Conclusion

Models of financial crisis and contagion predict that an economic crisis may spread even to firms and national markets not directly exposed to the original shock, particularly those with more liquidly traded assets. More specifically, they predict that the crisis-induced abnormal returns and decrease in market liquidity would be correlated with investor borrowing constraints, risk aversion and information asymmetry. Using firm-level high frequency data, we empirically investigate cross market linkages in the average level of spread and depth and their volatilities for a sample of exposed and unexposed US stocks to the Asian currency crisis. Specifically, we examine the following questions: (a) How much do the average level and volatility of spread and depth change during the Asian crisis for the exposed and unexposed firms (the 'liquidity crunch and contagion' hypotheses)? Is there a causal pattern in the liquidity dynamics between the exposed and unexposed market segments? (b) Do more liquid or more risky firms in the pre-crisis period suffer a greater loss of market liquidity during the crisis period (the 'flight to liquidity and quality' hypotheses)? (c) Do exposed and unexposed firms that experience a greater loss of market liquidity suffer more negative crisis-induced abnormal returns (the 'liquidity-wealth effects' hypothesis)?

Our results uncover evidence of contagion in market liquidity, we find that the Asian crisis period was characterized by an across-the-board increase in spreads accompanied by a decrease in market depth. Further, our results show an increase in the volatility of spread during the crisis period, underscoring that the liquidity crunch occurs for both exposed and unexposed companies. We also find that firms that are more risky during the pre-crisis period experience a larger increase (decrease) in bid-ask spread (depth) and liquidity risk during the crisis. However, our findings on the long-term effects of the crisis on market liquidity are mixed, perhaps due in part to the expansionary monetary policy of the Fed. Finally, our results show that both exposed and unexposed firms that suffer a greater loss of market liquidity due to an economic shock are associated with more negative abnormal returns during the crisis. These findings suggest that the widely documented contagion in stock returns is associated with a contagion in market liquidity during the Asian crisis.

Despite the statistically significant support for the main predictions of the models of crisis and contagion based on borrowing constraints, information asymmetry and risk aversion, it is noteworthy that the changes in the conventional measures of market liquidity explain just a fraction of the cross-sectional variation in abnormal returns during the Asian crisis. An important reason for this poor explanatory power is our focus on a sample of US stocks, which are removed from the epicenter of the crisis. Further, the traditional measures of spread and depth are a poor proxy for the true but unquantifiable demand and supply of market liquidity that is hidden in the investment strategies, internal and external borrowing constraints and risk preferences of investors. Also, it is perhaps due to the fact that we study primarily a sample of commercial and manufacturing firms whose assets are highly illiquid.[19] We expect market liquidity to play a much more important role in a crisis involving financial institutions which hold far more liquid assets and use high leverage. Therefore, the evidence we present is a very conservative account of the true but largely unquantifiable role of market liquidity in amplifying the original economic shock. ⅄

[19] Our sample contains two finance companies in the exposed group and four in the unexposed group.

References

1. Acharya V and Pedersen L (2005), "Asset Pricing with Liquidity Risk", *Journal of Financial Economics*, Vol. 11, No. 2, pp. 375-410.
2. Amihud Y and Mendelson H (1986), "Asset Pricing and the Bid-Ask Spread", *Journal of Financial Economics*, Vol. 17, No. 2, pp. 223-249.
3. Beck N and Katz J N (1995), "What To Do (and Not To Do) with Time-Series Cross-Section Data", *American Political Science Review*, Vol. 89, No. 3, pp. 634-647.
4. Bookstaber R (1999), "A Framework for Understanding Market Crisis", in *Risk Management: Principles and Practices,* AIMR, Charlottsville, VA.
5. Bookstaber R (2000), "Understanding and Monitoring the Liquidity Crisis Cycle", *Financial Analysts Journal*, Vol. 56, No. 5, pp. 17-22.
6. Brennan M J and Subrahmanyam A (1996), "Market Microstructure and Asset Pricing: On the Compensation for Illiquidity in Stock Returns", *Journal of Financial Economics*, Vol. 41, No. 3, pp. 441-464.
7. Brunnermeier M and Pedersen L (2005), "Market Liquidity and Funding Liquidity", Working Paper, Princeton University.
8. Calvo Guillermo A (2004), "Contagion in Emerging Markets: When Wall Street is a Carrier", IEA Conference Volume Series, Vol. 136, pp. 81-94.
9. Chordia T, Roll R and Subrahmanyam A (2000), "Commonality in Liquidity", *Journal of Financial Economics*, Vol. 56, No. 1, pp. 3-28.
10. Chordia T, Roll R and Subrahmanyam A (2001), "Market Liquidity and Trading Activity", *Journal of Finance*, Vol. 56, No. 1, pp. 501-530.
11. Chordia T, Sarkar A and Subrahmanyam A (2005), "An Empirical Analysis of Stock and Bond Market Liquidity", *Review of Financial Studies*, Vol. 18, No. 1, pp. 85-130.
12. Claessens S, Dornbusch R W and Park Y C (2001), "Contagion: Why Crises Spread and How this Can be Stopped", in Stijn Claessens and Kristin J Forbes (Eds.), *International Financial Contagion*, Kluwer Academic Publishers, Norwell, MA.
13. Copeland T E and Galai D (1983), "Information Effects of the Bid-Ask Spread", *Journal of Finance*, Vol. 38, No. 5, pp. 1453-1469.
14. Demsetz H (1968), "The Cost of Transacting", *Quarterly Journal of Economics*, Vol. 82, No. 1, pp. 33-53.
15. Forbes K J (2004), "The Asian Flu and Russian Virus: Firm-Level Evidence on How Crises are Transmitted Internationally", *Journal of International Economics*, Vol. 63, No. 1, pp. 59-92.

16. Forbes K J and Rigobon R (2002), "No Contagion, Only Interdependence: Measuring Stock Market Co-Movements", *Journal of Finance*, Vol. 57, No. 5, pp. 2223-2261.

17. Goldstein M A and Kavajecz K A (2000), "Eights, Sixteenths and Market Depth: Change in Tick Size and Liquidity Provision on NYSE", *Journal of Financial Economics*, Vol. 56, No. 1, pp. 125-149.

18. Hasbrouck J and Seppi D (2001), "Common Factors in Prices, Order Flows and Liquidity", *Journal of Financial Economics*, Vol. 59, No. 1, pp. 383-411.

19. Huberman G and Halka D (2001), "Systematic Liquidity", *Journal of Financial Research*, Vol. 24, No. 2, pp. 161-178.

20. Kodres Laura E and Pritsker Matt (2003), "A Rational Expectation Model of Financial Contagion", *Journal of Finance*, Vol. 57, No. 2, pp. 769-799.

21. Kyle A S and Xiong W (2001), "Contagion as a Wealth Effect", *Journal of Finance*, Vol. 56, No. 4, pp. 1401-1440.

22. Lang L H P and Stulz R M (1992), "Contagion and Competitive Intra-Industry Effects of Bankruptcy Announcements", *Journal of Financial Economics*, Vol. 32, No. 1, pp. 45-60.

23. Lee C and Ready M J (1991), "Inferring Trade Direction from Intra-Day Data", *Journal of Finance*, Vol. 46, No. 2, pp. 733-746.

24. Liu W (2006), "A Liquidity Augmented Capital Asset Pricing Model", *Journal of Financial Economics*, Vol. 82, No. 3, pp. 631-671.

25. Masson P R (2000), "Multiple Equilibria, Contagion and the Emerging Market Crises", in R Glick and Hutchison (Eds.), *Financial Crises in Emerging Markets,* Cambridge University Press.

26. Pastor L and Stambaugh R F (2003), "Liquidity Risk and Expected Stock Returns", *Journal of Political Economy*, Vol. 111, No. 3, pp. 642-685.

27. Patell J M (1976), "Corporate Forecasts of Earnings Per Share and Stock Price Behavior: Empirical Tests", *Journal of Accounting Research*, Vol. 14, No. 2, pp. 246-274.

28. Perold A (1999), "Long-Term Capital Management", LP (C), Harvard Business School Publishing.

29. Roubini N (1998), "Chronology of the Asian Crisis and Its Global Contagion", available at http://www.rgemonitor.com

30. Stoll H R (1978), "The Pricing of Security Dealer Services: An Empirical Study of NASDAQ Stocks", *Journal of Finance*, Vol. 33, No. 4, pp. 1153-1172.

31. Yuan K (2004), "Asymmetric Price Movements and Borrowing Constraints: A Rational Expectations Equilibrium Model of Crises, Contagion, and Confusion", *Journal of Finance*, Vol. 60, No. 1, pp. 379-411.

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