LIQUIDITY, STOCK RETURNS AND OWNERSHIP STRUCTURE:

AN EMPIRICAL STUDY OF THE BOMBAY STOCK EXCHANGE

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ABSTRACT

We study the problem of illiquidity that afflicts the stocks listed on the Bombay Stock Exchange (B.S.E.). Trading on a regular basis is concentrated in only a few of the listed stocks. We examine this issue by empirically looking at the characteristics of firms leading to differential levels of trading frequency and also, the resultant effect on average returns. Based on the study of a random sample of 250 firms over the five year period - 1989 to 1993, we find evidence in favor of a liquidity premium for stocks on the B.S.E. Also, we find trading frequency is positively related to number of shareholders and shares outstanding. In addition, the ownership structure seems to matter, with concentration in the hands of insiders and government bodies having a deleterious effect on liquidity.

1. Introduction

In recent years, globalization of capital flows has led to the growing relevance of "Emerging Capital Markets". In particular, India is one of the countries with an expanding stock market that is attracting foreign funds. The Indian capital market has grown phenomenally due to the recently initiated liberalization process. For instance, between 1985 and 1992 the number of listed companies on the Bombay Stock Exchange (B.S.E.) increased from 4,344 to 6,480. In the same period, the market value of the listed companies increased from Rs.253 billion to Rs.3,541 billion (approximately US $110 billion). As a percentage of GNP, the market capitalization of the listed companies increased from 9.7% in 1985-86 to 57% in 1991-92. However, the stock markets in India are plagued by severe illiquidity with trading being very infrequent and concentrated in only a few stocks.

Around 85% of the trading volume on the B.S.E is from the Group 'A' securities which constitute about 88 companies. In fact, 32% of the volume is due to

only the 10 most active issues. In contrast, Joseph (1990) estimates that about 25% of the listed companies do not trade even once a year. In this paper, we examine this issue by empirically looking at the characteristics of the firms leading to the differential levels of trading frequency and the resultant effect on average returns for the stocks on the B.S.E.

Illiquidity as measured by the absence of continuous trading implies that there is an extreme mismatch between the available buyers and sellers at a given point in time. As early as 1968, Demsetz noted the possibility that the available pool of liquidity-motivated traders (who demand immediacy) may not arrive at the same time. The consequent order imbalance can be cleared only if there exist traders who are willing to absorb the excess demand or supply at a price concession, of course. In other words, the traders who want to buy immediately can do so at a higher price and, similarly traders desiring immediate sale have to accept a lower price. In India the liquidity traders do not have this facility at this time, since there are neither any pre-arranged dealers for the stocks nor a mechanism for aggregating limit orders. Therefore, at a given time, if there are no liquidity-motivated traders on one side of the transaction, then one would expect no trade to occur.

For the New York Stock Exchange, Demsetz (1968) has shown that the probability of the arrival of a trader - the transaction rate - depends on the number of shareholders. Since then, other authors such as Benston and Hagerman (1974) and Glosten and Harris (1988) have used it as a proxy for the extent of liquidity traders for a particular stock. Recently, Bhide (1993) argues that liquidity of the stock can be enhanced by having a more diffused ownership but at the cost of good internal monitoring. Also, Holmstrom and Tirole (1993) make a distinction between long-term

investors and short-term liquidity traders. The idea is that the ownership structure affects the level of liquidity of the stock. While several authors have used variables such as insider concentration as a proxy for the adverse-selection component of the bid-ask spreads, the effect of ownership structure on the level of liquidity has not been tested directly.

In this paper, we attempt to shed light on the factors causing differential levels of trading frequency on the B.S.E. by specifically focusing on ownership structure variables. Also, we investigate the effect of the lack of liquidity on the expected returns of the stocks. Amihud and Mendelson (1986) in a theoretical model predict a liquidity premium. We believe that our paper contributes to a better understanding of a hitherto relatively unresearched Emerging Market. Given the growing attention on India and its stock markets, the findings of this paper should be of interest to an international audience as well.

We conduct this study for a sample of 250 companies over a five year period - 1989 to 1993. We find evidence in favor of a liquidity premium in the Indian market and that diffused stock ownership has a beneficial impact on the secondary market liquidity. Also, liquidity is adversely affected by larger insider holdings or by government and financial institutions. The rest of the paper is organized as follows. In section 2, we provide an overview of the Bombay Stock Exchange. In section 3, we discuss the implications of differential liquidity across stocks. The data and empirical results are presented in section 4. We offer our concluding comments in section 5.

2. An Overview of the Bombay Stock Exchange

The Bombay Stock Exchange (B.S.E) is the largest, most active stock market in India. It accounts for 65-70% of all transactions in value terms and about 80% of market capitalization. As of 1991, 6,400 companies were listed on this exchange. The total number of shareholders in India is estimated to be about 15 million.

Classification: Listed securities are classified into Group A and Group B categories. Group A securities, also known as specified securities, can be traded with or without effecting deliveries. This facility called the *Badla*-system is equivalent to being able to short-sell and buy with borrowed capital. There are about 88 stocks in this category which contains the larger and more liquid stocks. Firms are selected by the B.S.E. based on the volume of transactions, market capitalization, public shareholding pattern, and payment of dividends. Transactions in Group B, also called the cash shares, are settled on the settlement day. Of course, this distinction does not exist since December 1993, when the SEBI (Securities Exchange Board of India) unilaterally banned the *Badla*-system.

Role of Members: Even though the stock exchange does not prescribe any functional distinction between members, the B.S.E. has a fairly well established specialization covering the following types: (i) commission brokers; (ii) floor brokers; (iii) odd lot dealers; (iv) *taravaniwalas* (jobbers or specialists); (v) *budliwalas* or financiers; (vi) dealers in non-cleared securities.

Commission brokers are members who buy and sell orders on the floor of exchange on behalf of their clients. The brokerage is currently 2.5% of the value of the contract. Floor brokers are actually authorized assistants or sub-brokers and they execute orders for any members of the exchange. They receive a share in the brokerage fees paid by the client to the commission brokers.

Taravaniwalas specialize in one or more of the listed securities and operate mainly on their own account. They help to maintain a continuous market by standing ready to transact and charge a spread to compensate them for their services. However, they are under no obligation to give two-way quotes or act as a dealer continuously for any particular stock. Currently, market-making arrangements are not available for all stocks. Reliable time series data on spreads are unavailable. A survey conducted by Gupta (1992) shows that spreads ranged from 0.2 to 4.5% for Group A shares and from 0.3 to 30% for Group B shares.

Budliwalas, acting as financiers, lend securities to those who have sold short or lend money to those who need funds to take delivery of securities that they have purchased. They act as the third-party (in between the buyer and the seller) in certain transactions involving Group 'A' stocks. Dealers in non-cleared securities perform a role similar to *taravaniwalas* but operate on Group B securities.

Trading System: By and large, floor trading is the principal trading arrangement in Indian stock markets. Trading is confined to members or their representatives. The brokers execute trades on behalf of their clients during the official trading session which lasts from 11:30 a.m. to 2:30 p.m. on weekdays. The trading floor contains several trading posts for the different securities. Potential buyers and sellers gather at the trading post where a particular security is traded[1] and bargain with an open out-cry system. The traders record the details of their consummated trades in "*sauda*" books. The "*sauda*" books are exchange-provided notepads and the entries in them are used as evidence in settling disputes.

[1] However, for most securities there are no designated trading-posts. Especially, for the smaller illiquid stocks, a trader has to encounter, by chance, another person that is interested in taking the opposite side!

Settlement Procedures: For Group A shares, settlement is done in three ways: (a) by delivering shares against payment; (b) by an offsetting trade, i.e. a purchase for a sale made earlier or vice versa within the account period; or (c) by carrying over the transaction to the next period. The following example illustrates the carry-over procedure. Suppose an investor buys 1,000 shares of XYZ Corporation at Rs.55 per share. On the settlement date, which is normally two weeks, XYZ sells for Rs.50 and the investor wishes to carry forward the transaction to the next settlement. However, stock exchange rules stipulate that all transactions conducted during an account period must be settled on the settlement date. So, the investor must find a financier to help her. Typically her broker will help her to find a *budliwala*. The *budliwala* finances an amount equal to the number of shares multiplied by the make-up price. (The make-up price is determined by the stock exchange authorities and is fairly close to the price on settlement day.) Assuming a make-up price Rs.50, the investor takes delivery of 1,000 shares by paying Rs.55,000. She provides Rs.5,000 and the *budliwala* puts up the other Rs.50,000. Now the investor sells the shares to the *badla* financier at the make-up price of Rs.50 and executes a resale contract for the subsequent settlement at a rate of Rs.50 plus the *badla* financing charge. For Group B shares, payment of money and physical delivery of shares takes place once in two weeks on the settlement date.

3. Implications of Differential Liquidity Across Stocks

Prior literature has focused on several definitions of liquidity. For instance, Lippman and McCall (1986) have defined liquidity in terms of the time that it takes to transact. Hasbrouck and Schwartz (1988) characterize a liquid market by its depth, breadth and resiliency. Depth refers to the existence of buy and sell orders near the

current market price, breadth is the existence of orders in substantial volume, and resiliency is the responsiveness of new orders to price changes caused by short-term order flow imbalances. Other authors such as Amihud and Mendelson (1986) define liquidity as the observable bid-ask spread. Bernstein (1987) reviews the various measures of liquidity and points out the pitfalls of using any single measure of liquidity. The focus of this paper is on implications of differential liquidity on asset pricing and the effect of ownership structure on liquidity.

3.1 Liquidity and Asset Pricing

Schwartz (1988) states that liquidity differs between assets traded within a market center. Such trading frictions have an impact on the price behavior of a security. Other factors being equal, thinly traded stocks are found to have wider bid-ask spreads and greater short-period price volatility. Also, market model beta coefficients are biased downwards. The issue of whether liquidity differences between assets traded within a market center have a substantial effect on asset prices is an important one. Amihud and Mendelson (1986) model the impact of liquidity on asset pricing. They measure liquidity by the bid-ask spread which is the cost of immediate execution. Their theoretical model posits, and their empirical results corroborate, that assets with wider percentage spreads yield higher returns on average and that investors with longer holding periods should select assets with wider spreads[2]. Amihud and Mendelson (1988) examine the costs and benefits of increasing liquidity. They find that by increasing liquidity, firms reduce their cost of capital and increase their value. They analyze the role of a number of financial management policies and institutional

[2] Eleswarapu and Reinganum (1993) raise some doubts regarding the robustness of the model using evidence with NYSE data. Krishnamurti and Park (1990) present evidence from the NASDAQ market to show that illiquid firms earn higher returns as compared to liquid firms all others being equal. They use trading volume as their measure of liquidity.

mechanisms in enhancing the secondary market liquidity of firms. The implication of these findings is that we need to move from the two-dimensional risk/return framework to a three-dimensional risk/return/liquidity framework.

There are several reasons why it is useful to study the relation between liquidity and asset pricing. First, prior studies have largely focused on the more advanced western capital markets. The association of liquidity with stock returns has not been tested in emerging capital markets. There are very important differences between the trading practices of the Bombay Stock Exchange and an advanced stock market such as the New York Stock Exchange. N.Y.S.E. is a continuous market (except at the beginning of each day) with specialists providing liquidity. Trades are consummated at the quoted prices of the specialist with negligible time delay. In B.S.E. there are no mandatory market-makers. Investors seeking liquidity are subjected to uncertainty regarding the transaction price as well as the time of completion of trade. Furthermore, the differences in liquidity across stocks are exacerbated by the B.S.E. practice of categorizing stocks into two groups. It is therefore interesting to study whether, in spite of the differences in the market microstructure, there exists a liquidity premium in the Indian stock market.

Second, the study of liquidity in the Indian stock market, which is plagued by severe illiquidity problems, is likely to be useful to investors in making their investment decisions. Since 1993, Foreign Institutional Investors (FII) have been allowed to invest directly in the Indian stock market. FIIs find it useful to invest in Indian stocks on account of expectation of higher returns coupled with potential diversification benefits[3]. FIIs as of now only include the most liquid stocks in their portfolios.

[3] The returns in the Indian stock market have had a correlation of -0.17 with the US market (S&P 500). Investing in the Indian market provides western investors with a classic opportunity for risk

Empirical evidence on the liquidity premium in the Indian stock market is likely to be informative for FIIs who would like to know the potential compensation for investing in the illiquid stocks.

3.2 Ownership Structure and Liquidity

Demsetz (1968) states that one of the important determinants of secondary market liquidity is the number of shareholders. As the number of persons currently holding a particular share increases, the number of market participants interested in trading the asset increases in direct proportion. Therefore, the number of transactions per unit time also increases. The number of transactions and the volume traded are observed to be highly correlated in Demsetz's study. Another consequence of an increase in the number of shareholders is the reduction in bid-ask spreads.

Benston and Hagerman (1974) observe a direct relation between a proxy for insider holdings and bid-ask spread. Insiders possess shares for the purpose of controlling the firm and have privileged access to price-sensitive information not available to the public. Market-makers in order to reduce their potential losses on account of trading with insiders and/or other informed traders widen their bid-ask spreads.

Holmstrom and Tirole (1993) study the role of the stock market as a monitor of managerial performance. The information content of stock prices improves with the liquidity of the secondary market. In a liquid market, speculators will devote more resources on monitoring since they will realize more of the potential gains. Concentrated ownership reduces liquidity and hence the benefits of market monitoring

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reduction. Their expectation of higher returns is due to the higher GNP growth in India as compared to advanced industrialized countries.

will accrue to all shareholders. Thus, stock market liquidity is shown to have both a private and social value.

Bhide (1993) argues that increased stock market liquidity due to diffused stock holding in the US markets has been achieved at the cost of good internal monitoring by block-holders. Currently, block-holders owning 10% or more of a firm's stock are considered to be insiders, and section 16(b) of the Securities Exchange Act in the USA places restrictions on their short-term trading. Corporate and pension fund managers do not wish to compromise on the fiduciary responsibilities to their constituents and, thus protect the liquidity of their investments. Therefore, they may restrict their holdings to less than 10% to avoid triggering the provisions of Section 16(b). With smaller holdings, block-holders have less incentive to provide internal monitoring. Bhide (1993) considers this loss of internal monitoring as the cost of providing liquidity.

Governmental regulatory agencies in India have historically favored policies that attracted small investors. New issues of capital have been made on a non-discretionary basis and investors who apply for a smaller number of shares have been favored. Also, listed companies paid taxes at lower rates than non-listed companies. This may be one main reason for many stocks to list on the B.S.E. even though they have very few shares owned by outsiders. Consequently, there is little information put out by these companies nor any actual trading in the secondary markets. Joseph (1990) finds that for about 50% of the stocks which did not trade even once a year, there is no publicly available earnings or dividend information!

However, ownership in stocks has also been concentrated in the hands of insiders, government and financial institutions. Typically, about 40% of shares were

held by insiders and about 15%-20% by financial institutions and government. At the extreme, public sector companies were wholly owned by the government of India and were absolutely illiquid. Even in larger private sector companies, it was not unusual to find governmental nominees sitting on the board of directors. The effect of ownership concentration on stock market liquidity in the Indian context has not been empirically studied.

Recently, the regulatory agency, Securities Exchange Board of India (SEBI), has started permitting private placement of stocks, increased the minimum amount of investment in public issues, and allowed companies to raise capital from Euro-Issues. These measures undermine the secondary market liquidity of stocks. An ostensible reason for these measures is to allow companies to raise capital at lower issue costs. But adequate attention has not been given to the potential adverse impact of these measures on the liquidity of stocks. We provide evidence on the effect of stock ownership patterns on liquidity in the Indian market which is plagued by extreme illiquidity.

4.0 Data and Empirical Results

Data on stock prices were obtained from the database of Dateline and Research Technologies Limited (DART). The DART database covers nearly 2,000 companies out of a total of nearly 6,000 listed companies on the Bombay Stock Exchange. The price data are available in computer-readable form and cover the period July 1988-June 1993. The data on shareholding pattern were obtained from DART and the Bombay Stock Exchange directory. The shareholding data contain the following variables:

Percentages held by insiders, public, and governmental financial institutions; total number of shares outstanding; and number of shareholders.

4.1 Sample

We selected 250 companies randomly from the 2,000 companies in the DART database. The price data were collected from the DART database while the ownership information was hand-collected from the B.S.E. directory as of the end of each year in our sample. Companies belonging to both Group A and Group B were selected to make our sample representative of the population as much as possible. Companies not in the DART database are likely to be infrequently traded stocks especially of small companies. Therefore, our sample systematically excludes the most illiquid stocks. All the currently available Indian databases (in computer-readable form) will quite likely suffer from the same bias.

4.2 Methodology

For each company included in the sample, we compute the monthly returns[4] for the period July 1989 to June 1993. We measure the liquidity of a stock by its trading frequency. Traditional liquidity measures such as bid-ask spread and trading volume are not available for Indian stocks[5]. We measure trading frequency as the ratio of the number of days the particular stock traded to the total number of days on which the stock exchange operated during each year.

4.3 Empirical Results

[4] Monthly returns are geometric means computed every year. That is, for each company we have one annual observation for monthly return. This is done to minimize the impact of severe non-trading on return measurement.

[5] Volume data are available for Group A stocks but not for Group B stocks. Our sample is mainly composed of Group B stocks. The Indian stock markets at present do not have mandatory market-makers. Therefore, bid-ask spreads are not available.

We first conduct a pooled time series and cross-section regression to estimate the impact of trading frequency on stock returns. Trading frequency and average monthly returns are computed once a year. We regress the average monthly returns of a particular stock on its trading frequency during the previous year. Firms are allowed to "die-out" in the middle of the year to avoid survivorship bias. Thus the actual number of stocks in a particular year will be in general less than 250. The results of regression I reported below indicate the existence of a liquidity premium for the most illiquid stocks. The negative coefficient for the trading frequency variable (Tra_Frq) is statistically significant at conventional levels (t = -2.71, p-value = .007). In this study we do not control for systematic risk and bid-ask spread. Due to infrequency of trading, we are unable to obtain the required number of data points for estimating the beta of the most illiquid stocks. Furthermore, the evidence of Fama and French (1992) indicates that control for size is more important than that of systematic risk[6].

(I) E(Returns) = 3.30 - 2.80 Tra_Frq

(-2.71) (t-statistics in parenthesis)

adj-R^2 = 0.007, N=870

It is common practice in studies of determinants of asset pricing to control for market capitalization. However, due to infrequent trading, we are unable to obtain year-end prices for the entire sample. Therefore, we use the number of shares outstanding as the proxy for size. By regressing average monthly returns on the trading frequency and number of shares outstanding (regression II), we find that the

[6] Fama & French (1992) present evidence that is consistent with a strong relation between returns and size, but they are unable to find a reliable relation between returns and beta.

trading frequency variable remains significant but the number of shares outstanding is not.

(II) E(Returns) = 3.71 - 3.26 Tra_Frq - 6.25 x 10^{-8} Shares Outstanding

(-3.31) (-0.80)

adj-R^2 = 0.014, N=654

We next regress average monthly returns on the trading frequency and the number of shareholders. The number of shareholders is a proxy for the transaction rate according to Demsetz (1968). According to him, there exists an approximate linear relationship between the number of transactions and the number of shareholders. We wish to test the relative importance of the liquidity proxies viz., trading frequency and number of shareholders. The results which are shown in regression III indicate significance for the trading frequency variable but the number of shareholders variable is not statistically significant.

(III) E(Returns) = 3.82 - 3.23 Tra_Frq - 5.75 x 10^{-7} No. of Shareholders

(-3.00) (-0.63)

adj-R^2 = 0.012, N=567

Next, we focus our attention on the relation between the liquidity variables and the shareholding pattern variables,. Average values of the variables are shown for each of the liquidity portfolios - LQ1 through LQ5. The portfolios are formed on the basis of the average trading frequency for each year and are rebalanced annually. LQ1 contains the lowest quintile of stocks based on trading frequency whereas LQ5 contains the most liquid stocks.

We observe from Table 1 that the average trading frequency of the least liquid stocks is only 0.41. This implies that these stocks do not trade for approximately 60% of the days. The average trading frequency increases to 0.79 for the second most illiquid portfolio (LQ2). The average trading frequencies of LQ3, LQ4, and LQ5 are 0.90, 0.97, and 1.00, respectively. The average number of shares outstanding increases from 4.119 million to 24.023 million from LQ1 to LQ5. The increase is not strictly monotonic. The average number of shareholders shows an increasing pattern from 11,007 to 149,594 from LQ1 through LQ5. Once again, the increase is not strictly monotonic. The descriptive statistics give us some idea of the effect of ownership structure on the observed liquidity. Liquid firms are characterized by a large number of shares outstanding and are owned by a large number of shareholders.

Table 1

Descriptive statistics of liquidity and shareholding variables for the five portfolios based on trading frequency

Portfolio Number	Average Trading Frequency	Number of Shares Outstanding (in millions)	Number of Share-holders	Percentage of Shares Held by Insiders	Percentage of Shares Held by Govt./FI	Percentage of Shares Held by Public
LQ1	0.41	4.119	11,007	43.13	15.94	40.92
LQ2	0.79	10.480	51,598	43.76	15.12	41.07
LQ3	0.90	7.720	33,335	42.98	15.92	41.16
LQ4	0.97	12.850	63,875	43.44	15.40	41.37
LQ5	1.00	24.023	149,594	42.85	20.30	36.82

Diffused ownership appears to be associated with higher trading frequency. The shareholding pattern is as follows: approximately 40% is held by the public, government and financial institutions hold 15-20% and the rest is held by corporate insiders[7]. We next use regression techniques to analyze the impact of shareholding pattern on trading frequency.

We regress trading frequency on number of shares outstanding and show the outcome in regression IV below. The number of shares outstanding has a positive effect on the trading frequency and the relation is statistically significant.

(IV) $E(Tra\_Frq) = 0.83 + 1.25 \times 10^{-9}$ Shares outstanding

(4.62)

adj-R^2 = 0.024, N= 828

We next regress trading frequency on number of shareholders and report the results in regression V. A strong statistically significant positive relation exists between trading frequency and the number of shareholders. Our results conform with those of Demsetz (1968) and Bhide (1993).

(V) $E(Tra\_Frq) = 0.83 + 1.04 \times 10^{-7}$ No. of shareholders

(3.20)

adj-R^2 = 0.013, N = 716

[7] We group governmental holdings with financial institutions such as Unit Trust of India, Life Insurance Corp., etc. The government, either directly through shareholdings or indirectly through directives, exercises a certain degree of control on the financial institutions. The government nominees serve on the board of directors of the FIs.

Regressions VI and VII test the effects of insiders' holdings and the holdings of government/Financial Institutions on trading frequency. As per our discussion in section 3.2, we expect an inverse relation (after controlling for other factors) between the holdings of insiders and liquidity as measured by trading frequency.

(VI) $E(Tra\_Frq) = 0.81 + 4.16 \times 10^{-9}$ Shares outstanding $- 1.74 \times 10^{-14}$ Shares held by insiders

(5.77) (-4.35)

adj-R^2 = 0.04, N = 828

Regression VI confirms that insiders' holdings have a deleterious effect on trading frequency after controlling for the total number of shares outstanding. In regression VII, we use holdings by government and Financial Institutions in addition to total number of shares outstanding to explain the trading frequency.

(VII) $E(Tra\_Frq) = 0.82 + 2.47 \times 10^{-9}$ Shares outstanding $- 3.61 \times 10^{-11}$ Govt. & FI Holding

(3.39) (-1.81)

adj-R^2 = 0.027, N=828

The government and financial institutions do not actively trade in their shares and hence, their shareholding effectively reduces the number of shares available for trading in the secondary market. Our results confirm this conjecture. The number of shares held by government / Financial Institutions variable has a negative and statistically significant effect on trading frequency (p-value = .07) after controlling for the number of shares outstanding.

5.0 Conclusions

Our results indicate that there exists a liquidity premium for stocks traded in the Bombay Stock Exchange. Size and diffused ownership have a beneficial effect on the liquidity measure. Liquidity is adversely affected by increasing the holdings of insiders, government, and financial institutions.

Our study has several implications. First, liquid firms face a lower cost of capital and, therefore have a higher market value. Liquidity enhancing measures are valuable in themselves. Increasing the number of shareholders and the number of shares by such actions as stock splits are some such measures. Diffused ownership has a beneficial impact on liquidity but comes with additional costs. The process of making public issues targeted at a very large number of investors is both time-consuming and expensive. These costs must be weighed with the benefits that accrue from better liquidity. The dynamics of costs and benefits of liquidity-enhancing measures is a fertile area for further research.

This study also pinpoints the effects of "long-term" investors, namely, insider holdings, and holdings of financial institutions and government. Issue costs are lowered when shares are sold to insiders, and to government and financial institutions, but at the cost of reduced liquidity. The ostensible argument for increasing the insider-ownership is better monitoring. Measurement of the benefit of improved monitoring versus the cost of reduced liquidity is another fruitful area for further research.

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