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Back from Beyond the Bid-Ask Spread: Perspectives on Liquidity

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Abstract

Research into the topic of liquidity has greatly benefited from the availability of data. Although bid-ask spreads were inaccessible to researchers, Roll (1984) provided a conceptual model that estimated the effective bid-ask prices from regular time series data, recorded on a daily or longer interval. Later data availability improved and researchers were able to address questions regarding the factors that influenced the spreads and the relationship between spreads and risk, return and liquidity. More recently transaction data have been used to measure the effective spread and researchers have been able to refine the concepts of liquidity to include the impact of transactions on price movements (Clayton and McKinnon, 2000) on a trade-by-trade analysis. This paper aims to use techniques that combine elements from all three approaches and, by studying US data over a relatively long time period, to throw light on earlier research as well as to reveal the changes in liquidity over the period controlling for extraneous factors such as market, age and size of REIT. It also reveals some comparable results for the UK market over the same period.

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1. Introduction

Research into the topic of liquidity has greatly benefited from the availability of data. Historically, even bid-ask spreads were inaccessible to researchers, Roll (1984) provided a conceptual model that estimated the effective bid-ask prices from regular time series data, recorded on a daily or longer interval. Later data availability improved and researchers were able to address questions regarding the factors that influenced the spreads and the relationship between spreads and risk, return and liquidity. More recently transaction data have been used to measure the effective spread and researchers have been able to refine the concepts of liquidity to include the impact of transactions on price movements (Clayton and McKinnon, 2000) on a trade-by-trade analysis. This paper aims to use techniques that combine elements from all three approaches and, by studying US data over a relatively long time period, to throw light on earlier research as well as to reveal the changes in liquidity over the period controlling for extraneous factors such as market, age and size of REIT.

2. Previous Research

Liquidity and its antithesis, illiquidity, have been extensively studied in equity markets. It can be argued that illiquidity influences expected returns, either because investors may be prepared to pay a premium for liquid stocks when the market is down (Chordia et al [2000], [2001]), or because in different phases of markets, investors perceive liquidity as a source of additional returns (see Acharya and Pedersen [2005], Amihud [2002]).

The connection between liquidity and the bid-ask spread is similarly well established since the larger the spread, the more expensive trading in the stock would be. And this, in turn, would imply that investors would be inhibited in exploiting perceived mis-pricing or minor adjustments to their portfolio position. Correspondingly as greater uncertainty arises about future prices, Bollerslev and

Melvin (1994) showed that the spread would increase in the foreign exchange markets. In other markets similar results have been demonstrated by Boothe (1988), Gwilym, Clare and Thomas (1998).

However it can also be seen that the size of the bid-ask spread is only one component of liquidity: Brennan and Subrahmanyam (1996) argue that the spread only accounts for the inventory costs which have to be relatively minor when compared with other costs of market making. For example, the depth of the market would affect the capacity of investors to trade since a market lacking depth would result in prices moving away from investors seeking to trade in larger quantities as the market makers adjusted their bid-ask prices, even though the spread might remain unchanged – Kyle (1985). Investors would therefore become aware that trading would be difficult in any large quantities in markets that lacked depth and might build in a risk premium to adjust for this source of risk. In this framework, the bid-ask spread is reflecting the tightness aspect, that is, the spread is only giving some indication of the transaction costs in a short-term round trip. Studies of the bid-ask spread have therefore assumed away the substantial minority of transactions that have taken place either within the spread or, perhaps for large trades, outside the quoted spread.

In an early study of liquidity and the bid-ask spread, Roll (1984) without access to the bid-ask spread data suggested that they could be estimated by reference to the serial-correlation of price changes (returns) on aggregated transactions. Roll's example used daily data and showed that the covariance between successive price changes depended, not on the flow of new information, but on the spread. Briefly, we can achieve an intuitive understanding of the model if we consider the path of three successive trades: Starting with an investor buying (at the market maker's offer price), the next trade could take place either at the market maker's bid or offer price. The following trade could likewise be at the market maker's bid or offer price. The relationship between successive price changes in these transactions would only be positive if successive trades caused the market maker to alter the bid-offer spread. In the absence of such movement, there could only be a negative (or zero) relationship between price changes if a buy order were followed by a sell order (or *vice versa*). Arguing that in an efficient market, the market maker would only change the bid-offer price at random intervals, Roll thus argued that the only systematic relationship between successive changes had to come from the occurrences of buy-sell or sell-buy orders.

He thus derived the relationship between the covariance of successive price changes and the spread, and showed that the sum of the spread components had exactly the same distribution as an individual component and that the covariance was independent of the number of periods (transactions) within the measurement interval. Thus average spreads could be estimated indirectly from the following:

$$E\left[\sum_t (\Delta p_t, \Delta p_{t+1}) / \tau\right] = -\left(\bar{s}\right)^2 / 4, \qquad \mathrm{t} = 1, \ldots, \tau \tag{1}$$

where $\bar{s}^2$ represents the average squared spread during the sample period of length τ, and p_t represents the stock price at time t. Of course this is a weak relationship since often buy (sell) orders will be followed by other buy (sell) orders and furthermore with thinly traded stocks, market movements may take time to be reflected in individual stock prices (causing a positive serial correlation in interval-based returns) but Roll's approach has been adopted as a standard technique to measure spreads. A recent example is Capozza, Hendershott and Mack (2004) in assessing the bid-ask spread in US stocks.

3. Derivation of Research Model

In assessing the behaviour of stock-liquidity, Clayton and McKinnon (2000) (hereafter C&M) concentrated their analysis on the impact of trades and looked at the change in stock price associated with the size of trade. This was a powerful approach to the problem, enabled by the researchers' access to trade-by-trade data. Our approach starts by examining the C&M model when applied to daily intervals rather than to trade by trade data.

The C&M model assumes a linear relationship between the change of price between two successive trades and (a) the volume of shares traded and (b) the difference between the direction of successive trades – see Brennan and Subrahmanyam (1996). This latter variable reflects the effective spread – if successive trades are in the same direction (e.g. a retail buyer initiated), the computed difference would be zero but if the directions were different the variable would be either +2 or -2. The price change in the changed case would therefore reflect (half) the effective price change between the market maker's bid and offer prices. On the question of volume, their model implies that a large buy order would shift market makers' prices upwards whilst small orders would have less effect.

Algebraically the relationship on a trade-by-trade basis is represented by

$$P_t - P_{t-1} = \lambda I_t Q_t + \phi(I_t - I_{t-1}) + \varepsilon_t \tag{2}$$

Where: λ = market depth or inverse liquidity parameter

ϕ = the effective transaction cost of the transaction

Q_t = the volume of stock traded

I_t = Direction Indicator where:

I_t = 1 for retail investor's initiated buy and

I_t = -1 for retail investor's initiated sell transaction.

In this formulation, the lower the impact of large trades, the more liquid would be the market. Thus over time, if the market were to become more liquid and deeper, it would be reflected in the estimated λ falling. C&M found that for their sample covering REITs in 1993 and 1996 that indeed the market became more liquid in 1996 than it had been in 1993. However as shown in equation (2), they were also testing for the effective bid-ask spread by the ϕ parameter and on the whole sample of REITs they were unable to find evidence that it had changed significantly between 1993 and 1996. They also identified that the changes in liquidity were most strikingly obvious in those REITs that were or became self advised and managed.

C&M inferred that their study had shown the value of trade-by-trade data and their results advanced the study of liquidity assessment significantly. However what remains unknown is whether their results derive entirely from the use of the disaggregated data or whether the changes in liquidity and market changes would have been revealed in traditional methods and data sources.

In our sample we are using daily returns and daily transaction volume so a natural approach is to ask what would happen if we were to take the aggregate of daily trades using the above formulation.

$$\sum_{t=1}^{n}(P_t - P_{t-1}) = \lambda\sum_{t=1}^{n} I_t Q_t + \phi\sum_{t=1}^{n}(I_t - I_{t-1}) + \sum_{t=1}^{n}\varepsilon_t \quad (3)$$

Summing equation (2) over the number of trades per day we derive equation (3) and we find that the LHS equals the price change (or return) over the day, the first variable on the RHS sums to the total net trade in the day and the second term represents the sum of transactions indicators. Since every transaction apart from the first and last appears twice with the opposite sign, all intermediate transaction indicators cancel except for the first and last. The term therefore does not have economic significance when aggregated.

Many of the studies of market liquidity have focused on the role of market makers and the bid-ask spread – see Bessembinder and Kaufman (1997), Glosten and Harris (1988), and of course Stoll (1989). Glosten and Milgrom (1985) look at the role of the specialists in a competitive market and argue that the market value (if information were widely available) would be within the bid-ask spread and that the spread is limited by the need to attract liquidity traders (i.e. depth providing investors) but is increased if the supply of insider information increases.

In this case, however, we are looking at the operation of the market including the contribution of other investors. Agents may act as intermediaries and match trades between their clients, orders may be held up by dealing desks in investing institutions leading to unfilled orders that have to completed by close of trading, day-traders may lead to trend-following behaviour in trades and other institutional investors may be holding limit orders not passed onto the market maker. In other words, the liquidity of the market depends on much more than the trade-by-trade behaviour of any formal market maker. Efficient price behaviour will require deep and wide markets involving different types of investor standing ready to trade at or near the current market price. Only in such markets would we expect prices to adjust quickly to new information. Some information will reach all investors at or about the same time so the price of the stocks may be expected to move quickly with or without trading. Volume of trade will, in those instances, carry little or no information about the significance or the cause of the price change. In other cases, some investors may trade on the basis of more information than other investors (or with different expectations). In a market which has depth and is operationally efficient, such investors can trade stock at or about the current price since there are buyers and sellers standing ready to trade just above and just below the last traded price – see Holthausen et al. (1987).

In terms of simple market economics, we can envisage a highly elastic demand curve for stock at the current price – some of which is provided by the market maker but the bulk of which is provided by other investors in the market. If the market lacks depth, investors wishing to trade will find that the price has to move more to encourage buyers or sellers. By analogy, they will face a downward demand curve if they wish to sell and an upward sloping supply curve if they wish to buy. This suggests that depth in the market will allow investors to trade without the market price changing whilst information flows may result in price changes without significant trading. The slope of the demand/supply curve will reflect the effective depth of the market.

Diagrammatically we can represent this model as Figure 1 below.

[INSERT FIGURE 1 HERE]

Algebraically we can represent these functions as two linear equations with different intercepts and slopes. This allows us to hypothesise a relationship of the form:

$$\sum_{t=1}^{n}(P_t - P_{t-1}) = \alpha_0 + \alpha_1 Dup + \alpha_2 Ddown + \lambda_0 \sum_{t=1}^{n} Q_t + \lambda_1 Dup \sum_{t=1}^{n} Q_t + \lambda_2 Ddown \sum_{t=1}^{n} Q_t + \varepsilon_t \quad (4)$$

where *Dup* and *Ddown* are dummies that reflect whether the market price has risen or fallen during the day. In this model, market-wide information that is not accompanied by systematic trading is captured in the constant α_0 and the residual error terms ε_t. Note that the first intercept term is not redundant because it reflects the returns on days on which no trade takes place.

The upside and downside price changes are given respectively by equations (5) and (6:)

$$r_t = \alpha_0 + \alpha_1 + (\lambda_0 + \lambda_1)\sum Q_t + \varepsilon_t \quad (5)$$

$$r_t = \alpha_0 + \alpha_2 + (\lambda_0 + \lambda_2)\sum Q_t + \varepsilon_t \quad (6)$$

where and $r_t = \alpha_0$ when $Q_t = 0$.

In this formulation, we are measuring the gross trade on the assumption that the market makers are not systematically adding to or reducing their inventory. We recognise that this is an empirical assumption that will not hold in the very short term but, over sufficiently long series of trades, it becomes a reasonable working assumption.

The slopes represent the market depth (λ_i) in that the smaller the absolute slope, the more liquid the market is and the more stock the market can absorb or supply at a price that does not differ much from the current price. The intercept terms (α_i) provide some insight into the transaction costs in the market since the sum of the absolute values of the α show the minimum difference between buy and sell orders. They thus correspond to the estimate by C&M of the transaction costs[4] and we therefore use the symbol α to refer to the sum of the absolute values of the intercepts. However, we also incorporate Roll's estimator by including a lagged term in returns (change in prices) from which we can estimate the covariance between successive (daily) price changes (ρ). The full regression is therefore given by:

$$r_t = \alpha_0 + \alpha_1 Dup + \alpha_2 Ddown + \lambda_0 \sum_{t=1}^{n} Q_t + \lambda_1 Dup \sum_{t=1}^{n} Q_t + \lambda_2 Ddown \sum_{t=1}^{n} Q_t + \rho r_{t-1} + \varepsilon_t \quad (7)$$

where r_t represents the (log) of daily price changes, and ρ is the coefficient from which the serial covariance can be estimated – see Capozza, Hendershott and Mack (2004). We note that the inclusion of the lagged returns does not influence the estimation of the other coefficients (please see Figures 4 and 5 below).

We run yearly regressions on daily observations for each company showing at least 60 data points. We only report annual average estimates of coefficients, along with the R^2 of the regression and the number of REITs available in that particular year. If all REITs show a full time series for all variables, the maximum

[4] Actually the estimate here should be less than the C&M estimate since their parameter applies to those trades where at least one more order is executed and therefore will represent the average transaction unit of volume.

number of regressions would be 2,392 for the overall sample (184 REITs * 13 years).

4. Data

Daily price indexes and trading volumes of 184 REITs were obtained from SNL Financials, which also provided REITs characteristics (e.g. stock exchange). Bid and ask prices were recorded from Reuters for a smaller sample of US REITs which we use only for comparative purposes.

The bid-ask spread for REIT *i* at time *t* has been subsequently obtained as follows:

$$SPREAD_{i,t} = \frac{PA_{i,t} - PB_{i,t}}{0.5 * \left(PA_{i,t} + PB_{i,t}\right)}$$

where $PB_{i,t}$ and $PA_{i,t}$ respectively represent the bid and ask price for company *i* at time *t*.

Table 1 contains main descriptive statistics for price changes and trading volumes.

[INSERT TABLE 1 HERE]

5. Observations and Hypotheses

Real estate sector returns are illustrated in Figure 2, showing the relative performance of the sample of REITS in comparison with the overall equity market. As can be seen, the REIT's relative performance improved from 1994 and continued to out-perform the rest of the market until 2000 when it fell both relatively and absolutely until the end of 2002. Thereafter, it performed pretty much in line with the rest of the equity market until the end of 2005.

[INSERT FIGURE 2 HERE]

Turning to the reported spreads, in Figure 3 we show the reported spreads for REITs from 1991 onwards. The striking feature for the market is the peak in 1993. This appears consistent with the finding of C&M that liquidity had increased between 1993 and 1996. In fact the change appears to have taken place early in that interval because reported spreads fell sharply in 1994.

[INSERT FIGURE 3 HERE]

From previous research, the received view is that, after a rise at the end of the 1980s, spreads fell in the 1990s [Nelling et al. (1995)]. However, it was also shown that from 1993 to 1996 REITs spreads fell, not because there was a general reduction in REIT spreads, but because new REITs appeared on the market and they were more marketable and more liquid than the old REITs – see Cole (1998). The new REITS had significantly lower spreads than the old ones and that therefore the effect was to lower the average spread on REITs.

From the previous work and from the above discussion we therefore would expect to observe the following:

Market Depth 1993 onward: The slopes (which reflects the inverse of the market depth) of the positive return days should be positive and the negative return days should be negative. The slopes would become flatter (reflecting increasing market depth) from 1993 to 1996 and later as the REIT market continued to develop and expand.

Roll Estimate and Reported Spread: The Roll estimated effective spreads should be positively related to the spreads reported by Reuters.

Market Depth (λ) and Reported Spreads (or Roll Estimates): The estimates of market depth, from equation (7), would be related to the bid-ask spreads reported by Reuters or the Roll estimates.

Illiquidity Costs (α) and Reported Spreads (or Roll Estimates): The estimates of illiquidity costs (represented by the sum of the absolute values of the intercepts) from equation (7), would be related to the bid-ask spreads reported by Reuters[5] or the Roll estimates.

New vs. Old REITS: There should be more liquidity for the new REITs introduced in the market post-1993

NYSE vs. other markets: The NYSE should be more liquid than the other markets (ASE and NASDAQ)[6]. In exploring this question, we have to deal with the complication that large cap REITs would be expected to be more liquid than small cap REITs and that the market effect might therefore be confused with a size effect. We therefore include in our analysis some further exploration of the size and market effects.

6. Regression Results

Before reporting the results of the model regressions, we should consider alternative inferences of the regressions. For example, we are regressing the returns on volume, but it might be thought that the direction of influence is from returns to volume. Might not changes in the prices lead to more trade taking place? In support of our interpretation, Clark (1973), Karpoff (1987), Tauchen and Pitts (1983) argue for trading volume proxying for the flow of new information and the

[5] Glosten and Harris (1998); Lin et al. (1995).
[6] Bessembinder and Kaufman (1997); Chan and Lakonishok (1997); Huang R.D. and Stoll H.R. (1996).

level of disagreement between traders (which we identify with market depth). For an interesting extension of their work, see Rodgers, Satchell and Yoon (2001).

Notwithstanding the thrust of previous research, as a precautionary step, we first conduct Granger causality tests on the individual stock returns / trading volume data. The results showed little of significance. Overall, of the 2762 Granger regression tests, 12.9% suggested that daily volume Granger-caused daily returns whilst 9.7% suggested that daily returns Granger-caused daily volume (at the 95% confidence level). Only in 1995, was it found that there were more instances of returns Granger-causing volume (14.8%) than volume causing returns (11.5%). These results also argue against momentum-trading effects since momentum trading would cause volume to rise in response to price changes. The Granger-causality results suggest that this was not a dominant issue that affected stock prices in the sample used in this study. We take up the issue of momentum trading later when discussing the Roll-estimating procedure.

Market Depth 1993 onward

Table 2 summarises the results of the regression shown in Equation (7) for each year from 1993 to 2005 for our sample of US REITs. The slopes are correctly signed. There is a trend over time of the intercepts becoming closer to each other, implying improving liquidity in the market. However the positive slope diminishes sharply for 1993 and 1994 whilst increasing again in 1999, 2000 and 2004. This would be consistent with the liquidity of the market improving in the early 1990s whilst deteriorating in the later years since larger volumes would have been associated with larger price changes.

[INSERT TABLE 2 HERE]

Although there is substantial variation between the regression results for each company, the strength of the regressions is clearly indicated by the average adjusted R^2 for the regressions which are all larger than 55%. The daily data are noisy and we would not expect the regressions to explain variation in returns very strongly. We calculated the proportion of significant estimates for this regression and show the results in Table 3. It is interesting that in the early part of the period, the results were strongly significant in the majority of cases. As time progressed, the slopes of the regressions decreased and thus it is not surprising that the proportion of significant parameters also declined. This is consistent with increasing liquidity (lower slopes) as the market develops.

[INSERT TABLE 3 HERE]

We also show Figures 4 and 5 which summarise the average parameter estimates per year obtained either including – equation (7) – or excluding – equation (4) – the autoregressive parameter. The graphs show the AR parameter is not significantly changing the results (with the exception of 1993, where the sign and magnitude of the slope is nevertheless more than acceptable).

[INSERT FIGURES 4 & 5 HERE]

Roll Estimate and Reported Spread:

The relationship between the reported spreads and the estimated spreads using the Roll's procedure on the AR parameter estimate in equation (7) is shown in Figure 6. The downward movement is clearly revealed between 1993 and 1994 in both series with the Roll estimator, which is a measure of effective spread being, as expected, much smaller than the reported spreads. It is also important to note that the Roll estimator implies a negative covariance between successive period returns. The existence of plausible numbers for Roll's estimator confirms the absence of positive serial correlation of returns and suggests the absence of momentum-based trading.

[INSERT FIGURE 6 HERE]

Market Depth and Reported Spread

Turning to our measure of market depth, we represent the liquidity of the market by the difference between the slopes of the regressions (or alternatively the sum of the absolute values of the slopes), reasoning that if the slopes became steeper, it would imply less liquidity so the sum of the absolute values of the slopes would reflect increasing or decreasing liquidity. The results of the regression are reported in Table 4. As can be seen, there is a strong positive and significant relationship between the two estimates which is consistent with our expected relationship.

[INSERT TABLE 4 HERE]

New vs. Old REITS

The next issue that concerns us is the liquidity of the new and old REITs. Dividing our sample into the REITs that existed before 1993 and those that have appeared since that year, we ran the regression – equation (7) – for both samples. The signs of all the liquidity parameters were as expected. Furthermore the intercepts for old REITs are always outside those for new REITs, whilst the slopes for old REITs are always steeper than those for new REITs throughout the period (please see Tables 5 and 6).

Furthermore, consistent with prior research, if it is the old REITs that have shown such variation over the period in liquidity, new REITs have been more liquid and less affected by year to year changes in market conditions.

[INSERT TABLES 5 & 6 HERE]

NYSE vs. other markets

The final question that we choose to answer for the REITs concerns the liquidity of different markets. We divided our sample into NYSE and other markets and ran the regression of equation (7) on both sub-samples. The estimates conform closely to our expectations (please refer to Tables 7 and 8). NYSE REITs appear more liquid and more efficient in transaction costs throughout the period; the intercepts are closer to zero and the slopes are less steep than those in other markets.

[INSERT TABLES 7 & 8 HERE]

As mentioned above, however we note that large cap REITs would be expected to be more liquid than small cap REITs and that this effect might confound the market effect. In order to investigate this issue, for the years 2001 to 2005, we regress (1) the estimated liquidity parameters (the sum of the absolute slopes) and (2) the estimated transaction costs (the sum of the absolute intercepts), against size (represented by the log of total assets) and a market dummy. (There were insufficient observations of the non-NYSE REITs before 2001 to include earlier years).

The results are given in Table 9 below. The regressions were estimated using a dummy (1,0 for the NYSE), size and the interaction between the market and size (which has the effect of estimating the change in slope of the size effect). Turning first to the regression of market liquidity, we note that in every year (apart from 2003) the effect was that NYSE stocks were more liquid than non-NYSE stocks, large stocks were more liquid than small stocks but the effect of size was smaller for NYSE stocks. In other words, once a stock was listed on the NYSE, the size effect was less important than if it was not quoted on the NYSE. Thus the NYSE provided liquidity more than might be expected from the size effect alone.

[INSERT TABLE 9 HERE]

The transaction costs regressions show a similar picture. Costs are lower for NYSE stocks than for other markets and are lower for large companies. However the effect of being on the NYSE is that transaction costs is less pronounced than it would be if the stocks were traded on other markets.

7. Perspective on Results from a UK viewpoint

In order to show the robustness of our technique, we collected daily data from the UK market referring to 37 major property companies composing the FTSE 350 real estate sector index. DataStream was the main data source for all types of information used in our analysis and we were able to obtain stock prices (total returns), trading volumes (i.e. sum of the value of all transactions taking place on any day[7]) and bid and ask prices at the end of each day. In the UK throughout the late 1980s there was a boom in real estate with considerable activity in the market, but after the reaction in the early 1990s when real estate lost much of its perceived attractiveness, the period saw some shrinkage of the real estate sector since several companies were subject to private equity or management buy-outs as the property companies were seen to under-perform, (in terms of capital values), their estimated value of property held within their portfolio. A significant difference in price changes could be observed from 2003 onwards, when property companies started to become more attractive than other equities (the index increased from a value of 150 at the end of 2002 to a value of 350 at the end of 2005).

In order to contrast the UK and US real estate sector, we show Figure 7 which presents the reported spreads for both markets. Surprisingly, there is some common movement in reported spreads over the first part of the period; spreads fall in the UK market from a high in 1992 to 1994 where they remain with minor changes for the rest of the period.

[7] Since trading volumes are collected in British Sterling, UK results are not “directly” comparable to US figures.

[INSERT FIGURE 7 HERE]

In the UK market we could potentially run 520 regressions (40 property companies * 13 years) but like the US regressions, this was reduced because of the need to have a sufficient number of observations in each year. Table 10 presents the results for the regression – equation (7) – on the property companies in the sector for each year in the sample. The results show slightly decreasing intercept dummies, with absolute values passing from 1.25% in 1993 to 0.75% in 2005 for both positive and negative estimates thus representing slight falls in transaction costs. The steepness of the slope shows a substantial change between 1993 and 1994 and an almost constant liquidity throughout the rest of the period albeit with a greater variability than for US REITs.

[INSERT TABLE 10 HERE]

We were unable to compute Roll's estimates as the sign of the covariance was consistently positive, preventing us to obtain the suggested measure of effective spreads. Because of this result, we were unable to run the second regression of the inverse liquidity against the Roll estimator. Instead, we regressed the annual reported spreads against the inverse liquidity measure (the sum of the absolute slopes). Liquidity has been improving in the UK market, with both the reported spreads and inverse liquidity showing a decline over the period. This suggests that notwithstanding the difficulty of extracting the Roll estimator, the regression is indeed revealing characteristics of liquidity. From Table 11, which reports the results of the regression, it is clear that the relationship between the reported spreads and the inverse liquidity is weaker than in the US, but still significant at the 10% level.

[INSERT TABLE 11 HERE]

8. Conclusions

Data availability is an issue that inhibits some research into market microstructure, but in this paper we have developed a simple technique which, when used on daily stock price returns, appears to be consistent with the results of previous research obtained using transaction-level data. Whilst we do not pretend that our technique is superior to that of using transaction-based data, our results are consistent with those of previous researchers and shed light upon the behaviour of market liquidity or market depth over the relatively long period since 1993.

We show that liquidity improved dramatically from 1993 to 1994 in the US REIT sector and as previous researchers have suggested, the improvements resulted largely from the introduction of new REITs. The degree of liquidity is related to both the size of REITs and the market on which their stocks are traded but the NYSE appeared to offer more liquidity than might have been expected for the larger companies traded on it. Although we reveal a similar trend in the UK, the statistical results of the UK data are less informative since the Roll estimator of effective spreads was not consistent with the data. There is however a common feature with the US: spreads fell and liquidity improved for real estate securities during the early 1990s and have changed rather less over the period since.

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Appendix 1: Figures

Figure 1: Hypothetical Relationship between Trading Volume and Returns

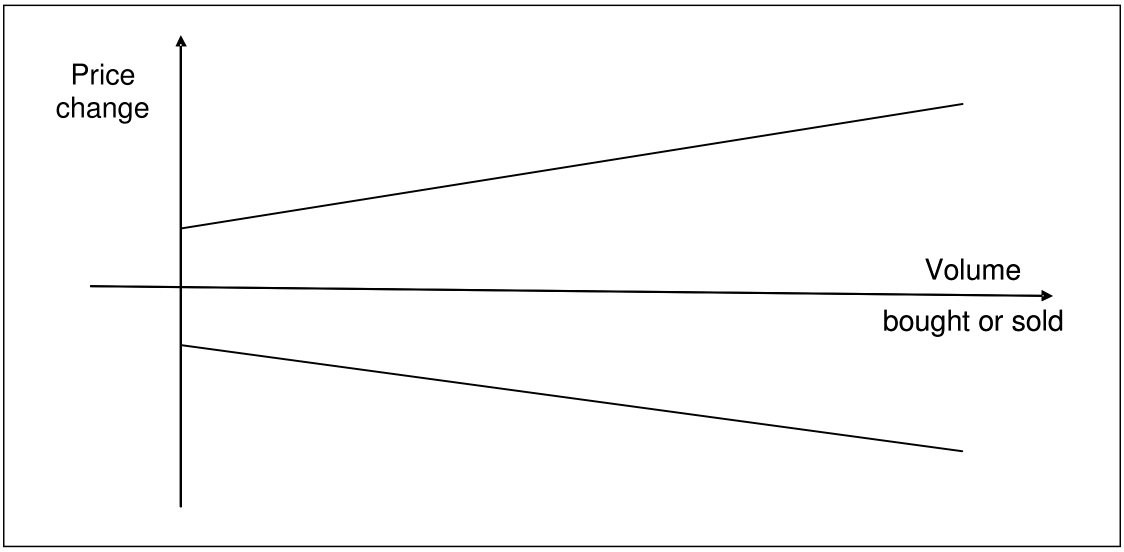


Figure 2: Performance of S&P 500 and SNL Equity REITs (1993-2005).

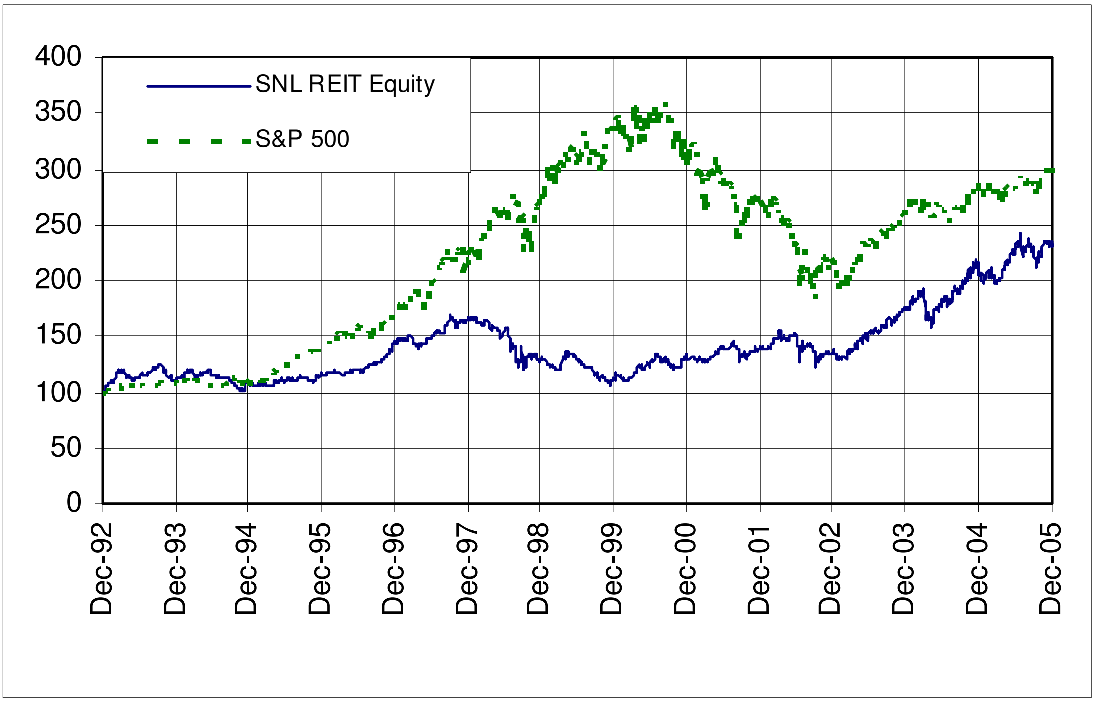


Figure 3: Reported Spreads: US REITs (1991-2005)

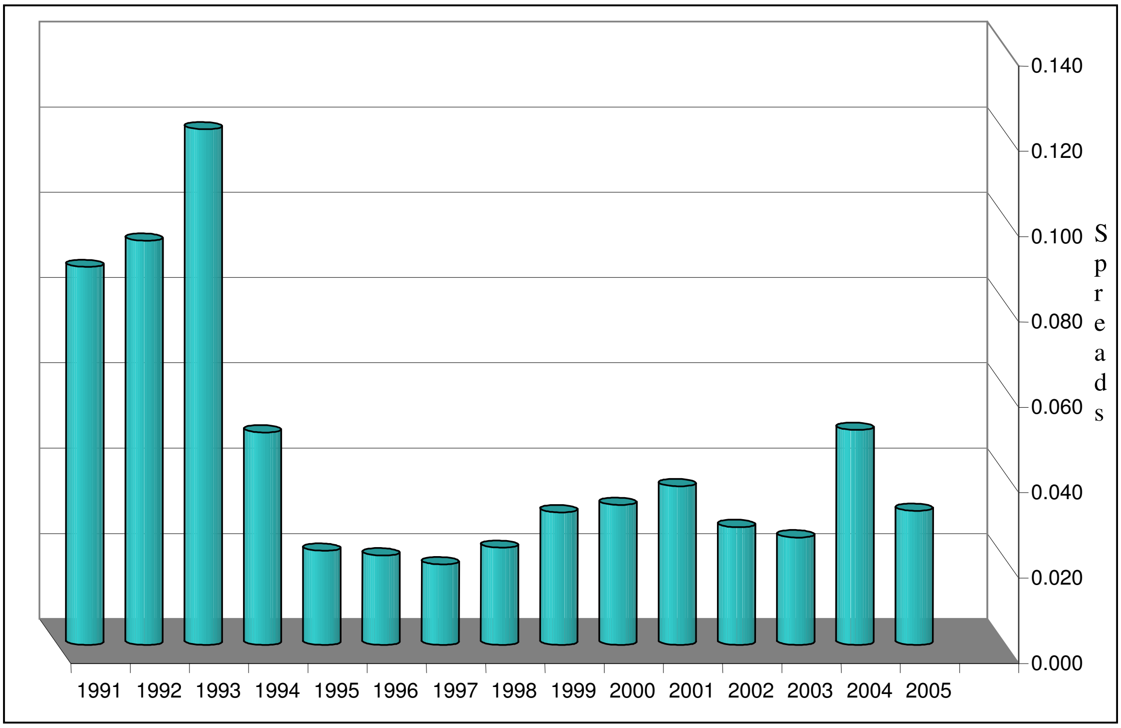


Figure 4: Regression Estimates for Intercept Dummies (including and excluding the AR1 parameter in/from the estimation) – US REITs (1993-2005)

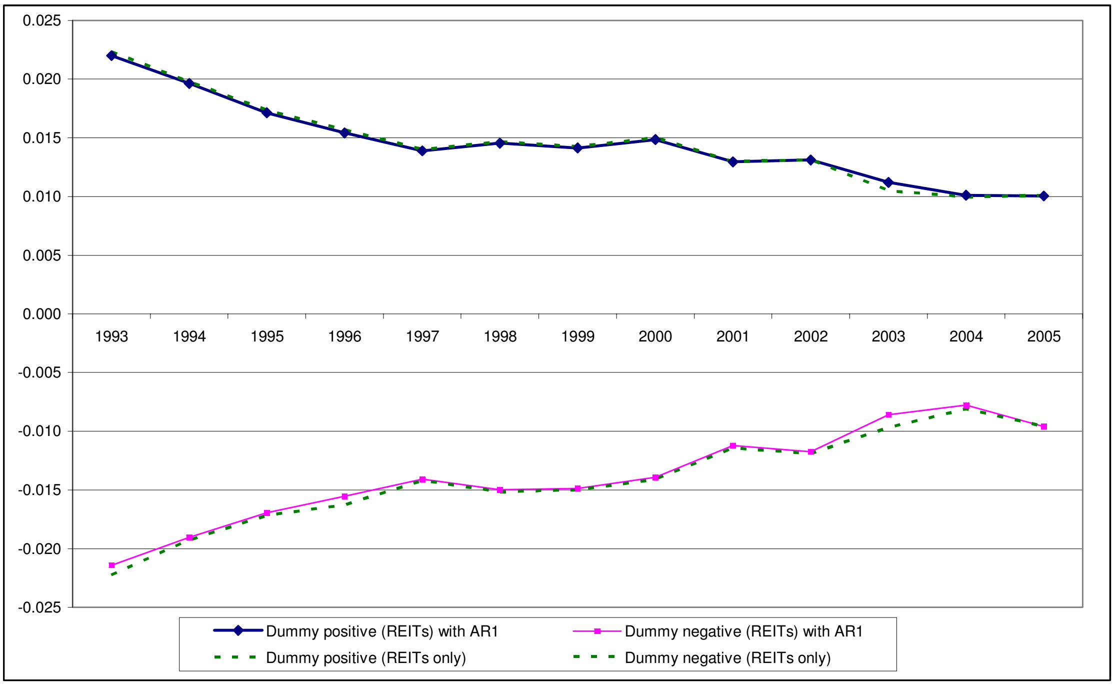


Figure 5: Regression Estimates for Slope Dummies (including and excluding the AR1 parameter in/from the estimation) – US REITs (1993-2005)

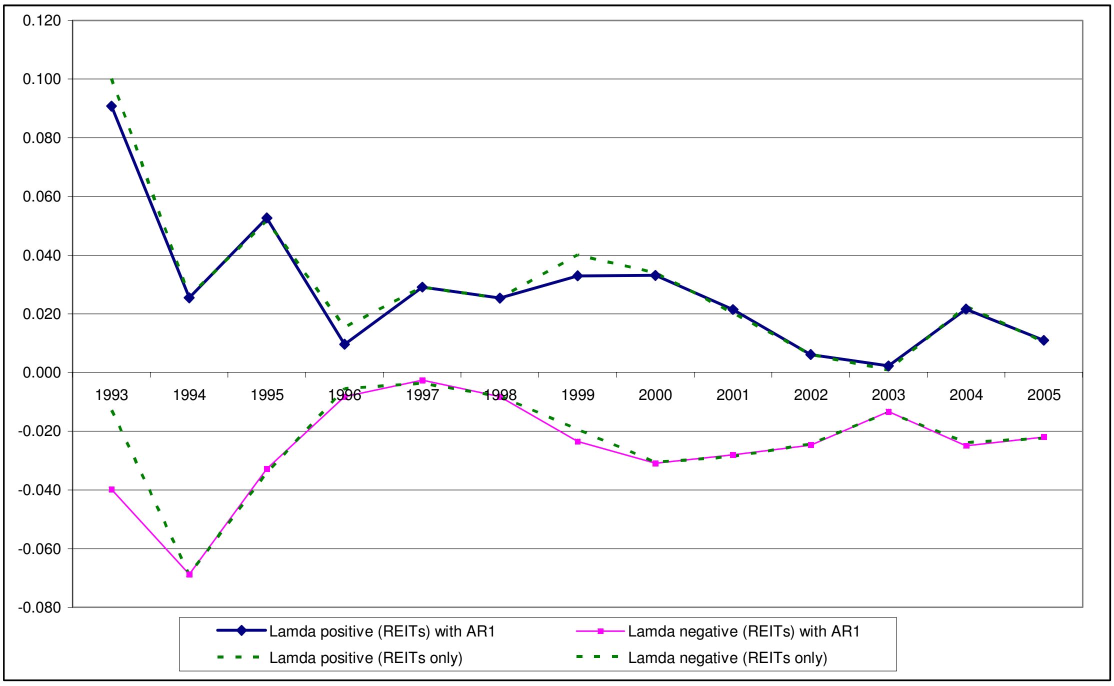


Figure 6: Time Series of US Reported Spreads and Roll Estimated Annual Spreads (1993-2005)

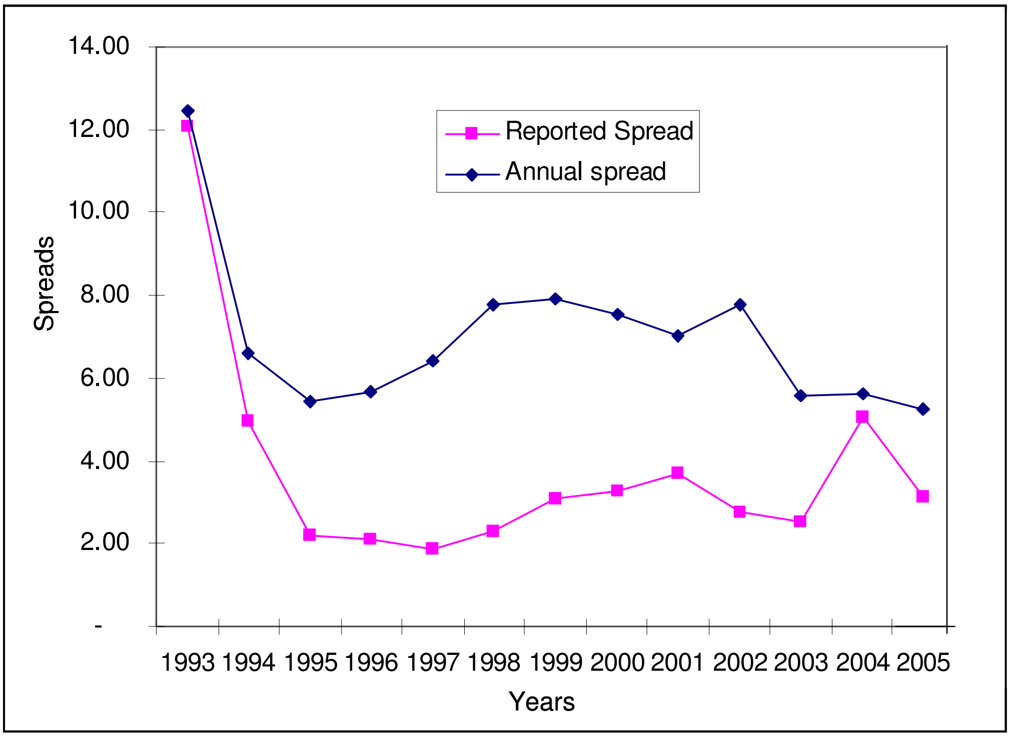
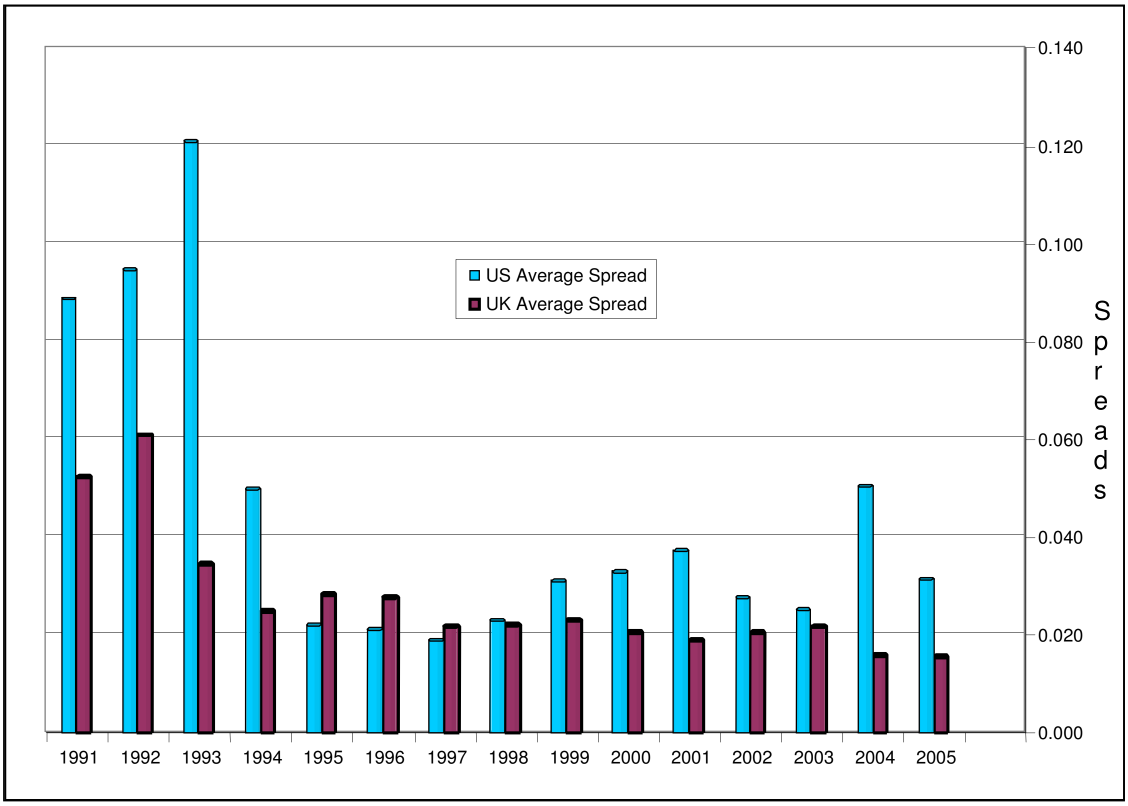


Figure 7: Reported Spreads: US and UK Markets (1991-2005)



Appendix 2: Tables

Table 1: Descriptive statistics of returns and volumes for US REITs (1993-2005)

	Returns		Volumes		
	Average	Cross-sectional Standard Deviation	Average	Cross-sectional Standard Deviation	No. of REITs
1993	0.04%	0.14%	120,008	591,199	68
1994	-0.03%	0.11%	41,562	44,968	95
1995	0.03%	0.18%	46,070	82,480	100
1996	0.06%	0.13%	58,820	68,465	106
1997	0.04%	0.20%	80,617	90,085	122
1998	-0.07%	0.18%	89,723	110,565	130
1999	-0.07%	0.09%	96,745	123,243	134
2000	0.03%	0.10%	101,340	128,090	134
2001	0.04%	0.11%	137,099	204,805	135
2002	0.00%	0.12%	164,381	233,229	143
2003	0.11%	0.09%	185,007	254,117	154
2004	0.10%	0.33%	225,361	266,995	174
2005	0.00%	0.22%	230,464	281,158	183

Table 2: Means of parameter estimates for regressions in US (1993-2005)

$$r_t = \alpha_0 + \alpha_1 Dup + \alpha_2 Ddown + \lambda_0 \sum_{t=1}^{n} Q_t + \lambda_1 Dup \sum_{t=1}^{n} Q_t + \lambda_2 Ddown \sum_{t=1}^{n} Q_t + \rho r_{t-1} + \varepsilon_t$$

	Constant a_0	Dummy		Lamda λ_0	Lamda dummy		AR ρ	R^2	No. REITs
		Positive a_1	Negative a_2		Positive λ_1	Negative λ_2			
1993	0.000	0.022	-0.021	0.011	0.091	-0.040	-0.019	0.70	61
1994	0.000	0.020	-0.019	0.001	0.025	-0.069	-0.011	0.73	90
1995	0.000	0.017	-0.017	0.001	0.053	-0.033	-0.015	0.74	98
1996	0.000	0.015	-0.016	-0.001	0.010	-0.008	-0.013	0.72	99
1997	0.000	0.014	-0.014	-0.003	0.029	-0.003	-0.010	0.67	113
1998	0.000	0.015	-0.015	0.000	0.025	-0.008	0.008	0.59	125
1999	0.000	0.014	-0.015	0.004	0.033	-0.023	-0.025	0.65	129
2000	0.000	0.015	-0.014	0.000	0.033	-0.031	-0.035	0.66	131
2001	0.000	0.013	-0.011	-0.001	0.022	-0.028	-0.027	0.59	130
2002	0.000	0.013	-0.012	0.000	0.006	-0.025	0.009	0.59	137
2003	-0.001	0.011	-0.009	0.007	0.002	-0.013	-0.036	0.62	150
2004	0.000	0.010	-0.008	-0.014	0.022	-0.025	-0.014	0.61	166
2005	0.000	0.010	-0.010	-0.001	0.011	-0.022	-0.003	0.61	179

Table 3: Proportion of Significant parameter estimates in the Regression

	Positive λ_1	Negative λ_2	Positive α_1	Negative α_2
1993	32.8%	23.0%	96.7%	98.4%
1994	24.4%	21.1%	100.0%	100.0%
1995	33.7%	20.4%	99.0%	99.0%
1996	28.3%	14.1%	100.0%	100.0%
1997	18.6%	15.9%	93.8%	94.7%
1998	15.2%	7.2%	68.8%	78.4%
1999	27.1%	13.2%	77.5%	83.7%
2000	16.0%	17.6%	79.4%	77.9%
2001	6.9%	10.8%	49.2%	42.3%
2002	2.2%	5.8%	35.0%	28.5%
2003	8.7%	8.0%	34.7%	34.0%
2004	3.6%	6.6%	28.3%	27.7%
2005	1.7%	3.9%	30.7%	30.7%

Table 4: Regression of Roll Annual Spreads against Inverse Liquidity Estimator (1993-2005)

$S_t = w_0 + w_1 \Sigma \lambda_{i,t} + e_t$			
	W_0	W_1	Adj R^2 0.32
Coefficient	0.655	4.706	
t-stat	(5.9)	(2.6)	
F-test	14.6	Prob.	0.0028

Table 5: Means of parameter estimates for regressions in US – Old REITs (1993-2005)

$$r_t = \alpha_0 + \alpha_1 Dup + \alpha_2 Ddown + \lambda_0 \sum_{t=1}^{n} Q_t + \lambda_1 Dup \sum_{t=1}^{n} Q_t + \lambda_2 Ddown \sum_{t=1}^{n} Q_t + \rho r_{t-1} + \varepsilon_t$$

	Constant	Dummy		Lamda	Lamda dummy		AR	R^2	No. REITs
		Positive	Negative		Positive	Negative			
	a_0	a_1	a_2	λ_0	λ_1	λ_2	ρ		
1993	0.000	0.024	-0.023	0.013	0.105	-0.048	-0.026	0.70	50
1994	0.000	0.022	-0.021	0.001	0.054	-0.132	-0.013	0.74	49
1995	0.000	0.019	-0.019	0.001	0.092	-0.067	-0.012	0.76	50
1996	0.000	0.017	-0.017	-0.001	0.016	-0.018	-0.013	0.73	48
1997	0.000	0.014	-0.015	0.001	0.014	-0.008	-0.017	0.67	48
1998	0.000	0.015	-0.017	0.000	0.041	-0.013	-0.005	0.62	48
1999	0.000	0.012	-0.012	-0.001	0.023	-0.017	-0.012	0.66	47
2000	0.000	0.017	-0.017	0.001	0.059	-0.060	-0.037	0.66	49
2001	0.000	0.017	-0.015	0.001	0.040	-0.021	-0.022	0.61	48
2002	0.000	0.013	-0.011	-0.001	0.013	-0.035	0.008	0.60	47
2003	-0.002	0.013	-0.008	-0.002	0.024	-0.022	-0.040	0.63	50
2004	0.000	0.011	-0.009	0.001	0.048	-0.042	-0.019	0.62	50
2005	0.000	0.013	-0.012	0.000	0.029	-0.063	-0.009	0.61	50

Table 6: Means of parameter estimates for regressions in US – New REITs (1993-2005)

$$r_t = \alpha_0 + \alpha_1 Dup + \alpha_2 Ddown + \lambda_0 \sum_{t=1}^{n} Q_t + \lambda_1 Dup \sum_{t=1}^{n} Q_t + \lambda_2 Ddown \sum_{t=1}^{n} Q_t + \rho r_{t-1} + \varepsilon_t$$

	Constant a_0	Dummy Positive a_1	Dummy Negative a_2	Lamda λ_0	Lamda dummy Positive λ_1	Lamda dummy Negative λ_2	AR ρ	R^2	No. REITs
1993	0.000	0.013	-0.016	0.004	0.024	-0.001	0.018	0.70	11
1994	0.000	0.015	-0.014	0.000	0.005	-0.005	-0.006	0.71	39
1995	0.000	0.014	-0.014	0.000	0.003	-0.007	-0.019	0.72	47
1996	0.000	0.014	-0.013	-0.001	0.004	-0.003	-0.011	0.71	51
1997	0.000	0.013	-0.013	0.000	0.004	-0.006	-0.005	0.66	63
1998	0.000	0.015	-0.014	0.000	0.009	-0.010	0.016	0.57	76
1999	0.000	0.012	-0.012	0.005	0.018	-0.011	-0.030	0.65	81
2000	0.000	0.013	-0.012	0.000	0.018	-0.014	-0.034	0.66	82
2001	0.000	0.010	-0.008	0.000	0.007	-0.015	-0.027	0.58	82
2002	0.000	0.013	-0.012	0.001	0.003	-0.020	0.009	0.59	90
2003	0.000	0.010	-0.008	0.000	0.005	-0.009	-0.036	0.61	100
2004	0.000	0.010	-0.007	-0.021	0.010	-0.018	-0.012	0.61	116
2005	0.000	0.009	-0.009	-0.001	0.004	-0.006	0.000	0.61	129

Table 7: Means of parameter estimates for regressions in US – NYSE REITs (1993-2005)

$$r_t = \alpha_0 + \alpha_1 Dup + \alpha_2 Ddown + \lambda_0 \sum_{t=1}^{n} Q_t + \lambda_1 Dup \sum_{t=1}^{n} Q_t + \lambda_2 Ddown \sum_{t=1}^{n} Q_t + \rho r_{t-1} + \varepsilon_t$$

	Constant a_0	Dummy		Lamda λ_0	Lamda dummy		AR ρ	R^2	No. REITs
		Positive a_1	Negative a_2		Positive λ_1	Negative λ_2			
1993	0.000	0.016	-0.016	0.009	0.066	-0.033	-0.013	0.70	48
1994	0.000	0.014	-0.015	0.001	0.031	-0.039	-0.007	0.71	74
1995	0.000	0.013	-0.013	0.000	0.036	-0.030	-0.010	0.73	78
1996	0.000	0.012	-0.012	0.000	0.007	-0.001	-0.009	0.72	80
1997	0.000	0.010	-0.010	0.000	0.007	-0.003	-0.006	0.66	87
1998	0.000	0.010	-0.010	0.000	0.008	-0.007	0.018	0.59	94
1999	0.000	0.009	-0.010	0.000	0.010	-0.007	-0.012	0.65	95
2000	0.000	0.010	-0.009	0.000	0.009	-0.010	-0.029	0.64	96
2001	0.000	0.008	-0.007	0.000	0.007	-0.010	-0.019	0.59	96
2002	0.000	0.008	-0.007	0.000	0.005	-0.007	0.028	0.59	99
2003	-0.001	0.009	-0.005	-0.001	0.004	-0.003	-0.033	0.62	103
2004	0.000	0.008	-0.005	0.000	0.005	-0.005	-0.007	0.62	116
2005	0.000	0.007	-0.007	0.000	0.003	-0.003	0.011	0.61	127

Table 8: Means of parameter estimates for regressions in US – Non-NYSE REITs (1993-2005)

$$r_t = \alpha_0 + \alpha_1 Dup + \alpha_2 Ddown + \lambda_0 \sum_{t=1}^{n} Q_t + \lambda_1 Dup \sum_{t=1}^{n} Q_t + \lambda_2 Ddown \sum_{t=1}^{n} Q_t + \rho r_{t-1} + \varepsilon_t$$

	Constant a_0	Dummy Positive a_1	Dummy Negative a_2	Lamda λ_0	Lamda dummy Positive λ_1	Lamda dummy Negative λ_2	AR ρ	R^2	No. REITs
1993	0.000	0.043	-0.042	0.020	0.183	-0.067	-0.039	0.74	13
1994	0.000	0.036	-0.033	-0.001	0.047	-0.215	-0.018	0.80	16
1995	0.000	0.035	-0.033	0.003	0.117	-0.044	-0.036	0.77	20
1996	0.000	0.031	-0.032	-0.006	0.021	-0.038	-0.029	0.72	19
1997	0.000	0.028	-0.028	-0.009	0.097	-0.021	-0.022	0.70	26
1998	0.000	0.029	-0.028	0.000	0.079	-0.026	-0.024	0.58	31
1999	0.000	0.029	-0.028	0.017	0.040	-0.069	-0.061	0.67	34
2000	0.000	0.028	-0.027	0.001	0.070	-0.055	-0.054	0.69	35
2001	0.000	0.024	-0.022	0.001	0.054	-0.038	-0.043	0.60	34
2002	0.000	0.028	-0.025	0.001	0.016	-0.069	-0.040	0.61	38
2003	0.000	0.016	-0.015	0.024	0.025	-0.037	-0.045	0.61	47
2004	0.000	0.015	-0.013	-0.047	0.034	-0.052	-0.031	0.61	50
2005	0.000	0.017	-0.016	-0.002	0.019	-0.046	-0.036	0.60	52

Table 9: Regression of (1) Inverse Liquidity (sum of the slopes, Panel A) and Transaction Costs (sum of the intercepts, Panel B) against (Log-)Size and Market Dummy

	Panel A: λ					**Panel B: α**				
	Coefficients				**F-stat**	**Coefficients**				**F-stat**
	Constant	**D Nyse**	**Size**	**Nyse*size**		**Constant**	**D Nyse**	**Size**	**Nyse*size**	
2001	1.24***	-0.995***	-0.09***	0.074***	10.15	0.347***	-0.304***	-0.024***	0.022***	17.30
	4.91	*-2.78*	*-4.40*	*2.72*		*6.47*	*-4.01*	*-5.57*	*3.85*	
2002	0.66***	-0.518***	-0.047***	0.038***	14.69	0.348***	-0.312***	-0.024***	0.022***	14.95
	5.95	*-3.23*	*-5.29*	*3.15*		*5.99*	*-3.72*	*-5.13*	*3.55*	
2003	0.41*	-0.35	-0.031*	0.03	1.28	0.226***	-0.171***	-0.016***	0.013***	22.37
	1.91	*-1.09*	*-1.77*	*1.12*		*7.93*	*-3.93*	*-6.82*	*3.93*	
2004	1.057***	-0.982***	-0.074***	0.069***	11.27	0.171***	-0.13***	-0.011***	0.009***	24.18
	5.04	*-3.10*	*-4.45*	*2.95*		*8.37*	*-4.22*	*-7.03*	*4.15*	
2005	0.911***	-0.865***	-0.064***	0.061***	11.91	0.214***	-0.157***	-0.015***	0.012***	28.79
	5.47	*-3.33*	*-4.94*	*3.24*		*9.48*	*-4.46*	*-8.29*	*4.53*	

* Significant at 90% confidence level
** Significant at 95% confidence level
*** Significant at 99% confidence level

Table 10: Means of parameter estimates for regressions in UK (1993-2005)

$$r_t = \alpha_0 + \alpha_1 Dup + \alpha_2 Ddown + \lambda_0 \sum_{t=1}^{n} Q_t + \lambda_1 Dup \sum_{t=1}^{n} Q_t + \lambda_2 Ddown \sum_{t=1}^{n} Q_t + \rho r_{t-1} + \varepsilon_t$$

		Dummy			Lamda dummy			
	Constant a_0	Positive a_1	Negative a_2	Lamda λ_0	Positive λ_1	Negative λ_2	R^2	No. Prop. Cos.
1993	0.000	0.012	-0.012	0.000	0.121	-0.007	0.61	14
1994	0.000	0.012	-0.011	0.000	0.048	-0.021	0.67	19
1995	0.000	0.012	-0.011	0.000	0.050	-0.048	0.72	20
1996	0.000	0.010	-0.009	0.000	0.044	-0.015	0.70	18
1997	0.000	0.013	-0.011	0.000	0.075	-0.041	0.56	20
1998	0.000	0.009	-0.009	0.000	0.016	-0.041	0.57	25
1999	0.000	0.011	-0.009	0.000	0.095	-0.047	0.56	25
2000	0.000	0.009	-0.008	0.000	0.015	-0.023	0.53	26
2001	0.000	0.008	-0.010	0.000	0.052	-0.030	0.53	32
2002	0.000	0.011	-0.011	0.000	0.032	-0.013	0.54	32
2003	0.000	0.011	-0.010	0.000	0.055	-0.029	0.55	32
2004	0.000	0.009	-0.008	0.000	0.034	-0.036	0.57	35
2005	0.000	0.009	-0.008	0.000	0.037	-0.011	0.57	39

Table 11: UK Regression of Reported Annual Spreads against Inverse Liquidity Estimator (1993-2005)

$RS_t = w_0 + w_1 \Sigma \lambda_{i,t} + e_t$			
	W_0	W_1	
Coefficient	0.011	3.04	Adj R^2 0.16
t-stat	(0.284)	(3.04)	
F-test	3.36	Prob.	0.096