Measuring financial market liquidity

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Abstract This paper introduces a new composite indicator of market liquidity, based on a series of measures developed in the academic literature. The indicator suggests that financial market liquidity was markedly lower in the summer of 2007, following a period of high liquidity. The indicator shows that market liquidity can fall rapidly in times of stress, highlighting the importance of managing this source of risk in the financial system. The views expressed in this paper are those of the author and not necessarily those of the Bank of England.

Keywords: *liquidity, liquidity risk, liquidity premium, bid-ask spreads, risk management*

INTRODUCTION

Liquidity is a slippery concept:[1] it can refer to at least three different things. The term 'global liquidity' is often used in relation to money supply around the world.[2] A second aspect to liquidity relates to the composition of a firm's balance sheets. In particular, banks face funding liquidity risk if they are not able to meet their cash-flow needs.[3] 'Market liquidity' refers to the ease with which financial assets can be bought and sold. In this context, liquidity risk occurs if an investor cannot easily offset or eliminate a position without significantly affecting the market price of the asset.[4]

These concepts are linked. An increase in global money growth may leave households and companies holding more monetary assets on their balance sheet than they would like. This may increase the demand for a range of other assets, including financial assets.[5] This can then drive up the general level of financial market activity, potentially increasing market liquidity over the medium term. There are clearly also other short-term factors that affect market liquidity, which can frequently change within one day. Some of these sources of illiquidity are discussed below. There is also a connection between funding liquidity and market liquidity. A firm facing funding liquidity risk may need to sell assets to meet cash-flow needs. But if asset markets are relatively illiquid, then the firm may be forced to sell them at a low price. In extreme events, feedback

loops between the two concepts may be generated. An initial fall in asset prices might trigger further asset sales, for example, to meet margin calls or because risk limits have been breached. Prices could then be driven down further, and so on.[6,7]

This paper focuses on financial market liquidity, developing a new indicator for the level of liquidity in a number of markets. The indicator was first published in the Bank of England's April 2007 *Financial Stability Report*.[8] It was subsequently described in an article in *The Economist*.[9] Charts of the indicator have been used to illustrate articles in the *Financial Times*[10] and the *International Herald Tribune*.[11]

MARKET LIQUIDITY AND LIQUIDITY RISK

Kyle (1985) proposes three dimensions to market liquidity.[12] The first is 'tightness', which can be measured by the bid-ask spread — the difference between the prices at which a financial instrument can be bought and sold. In some texts, this is called 'width'. Two other dimensions to market liquidity are 'depth' — the volume of trades possible without affecting prevailing market prices — this is also known as 'slippage' or 'price impact' — and 'resiliency' — the speed at which price fluctuations resulting from trades are dissipated. These dimensions are illustrated in Figure 1.[13] Another aspect of liquidity common in the literature is 'immediacy' — the speed with which trades of a given size can be arranged at a given cost.

The academic literature considers a number of sources of illiquidity.[14] Certain investors have private information, or are better able to process

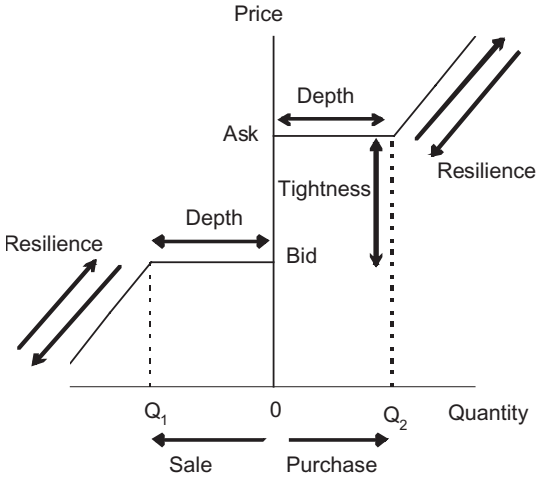

Figure 1: Dimensions of market liquidity
Source: Banque de France

information available to others. This creates an adverse selection problem as informed traders that have 'bad' news are likely to sell and *vice versa*. Market-makers therefore need to protect themselves against potential losses to better informed traders, thus giving rise to the bid-ask spread and thus the cost of trading faced by investors. Another possible source of illiquidity is so-called inventory risk. Essentially, markets can be fragmented so not all investors are present in the market at the same time. The gap between the arrival of sellers and buyers is bridged by market-makers who can buy from the seller and then later sell the same asset to the buyer. However, there is a risk that, in illiquid conditions, the market-maker may not be able to sell a security readily, or will only be able to sell at a greatly reduced price. Again, the bid-ask spread is used to compensate market-makers for this risk: if they expect markets to become less liquid, they will raise the bid-ask spread and thus trading costs. A third source of illiquidity is search costs that must be faced by investors wanting to trade. A seller needs to search for a

counterparty and then negotiate a price. These costs are likely to be greater in over-the-counter markets than in on-exchange markets, where the search is often undertaken through an electronic trading system and the search cost is replaced by a transaction fee.

In standard asset pricing theory, financial instruments with the same expected cash flows will have the same price, by the concept of 'no arbitrage'. Such traditional models do not account for differences in the liquidity of financial assets.[15] In general, an investor holding a financial asset with less liquidity will expect to receive greater compensation for holding this asset, *ceteris paribus*. This additional compensation is known as the liquidity premium.[16] This premium has been incorporated into some more recent asset pricing models, for example, by extending the capital asset pricing model.[17]

Market liquidity is important for the stability of financial systems as sudden changes in asset prices can adversely impact on key intermediaries in financial markets, such as banks. This can not only create losses in a trading book, but may also affect their ability to hedge market risks effectively and could impact on their capacity to distribute the risks that they have originated or securitised. Banks could also potentially make losses on their lending to counterparties who are active in financial markets. In general, the underlying non-financial assets in an economy are not necessarily easy to convert to cash, so the liquidity offered by financial assets requires confidence in the ability to transact. It relies on people continuing to believe that assets remain liquid. In securities markets these beliefs can be self-fulfilling. Liquid markets will attract trade to themselves while illiquid markets will be less attractive places to do business and may find it hard to attain the critical mass of trading that will give them liquidity. Liquidity can change, sometimes suddenly. If a piece of news makes an asset suddenly less attractive, and there is uncertainty to its new value, many holders will wish to sell, but potential buyers may be reluctant to come forward and it will not be possible for everyone to exit the market simultaneously.[18]

One example of the possible impact of illiquid financial markets is the events in autumn 1998 that ultimately led to the restructuring of the Long-Term Capital Management (LTCM) hedge fund. This crisis was triggered by the Russian authorities' decision in mid-August to revalue their currency unilaterally, leading to a fall in the rouble of more than 60 per cent that month. This had a widespread impact as the effects were propagated through global capital markets.[19] The crisis led to a sudden reassessment of risk appetite, with firms reducing their riskier positions. This induced falls in asset prices, which triggered an increase in margin calls, forcing highly-leveraged institutions to sell more assets, accentuating falls in prices. This feedback loop created the highly illiquid market conditions that led to rumours of difficulties at LTCM. The crisis culminated in late September with the Federal Reserve Bank of New York facilitating discussions among LTCM's major creditors, counterparties and investors leading to a $3.6bn private sector rescue. A number of these feedback mechanisms also operated in summer 2007: an account of these events

is given in the Bank of England's October 2007 *Financial Stability Report*.[20]

AN INDICATOR FOR MARKET LIQUIDITY

Given its importance, it is useful to measure financial markets' current level of liquidity and how this relates to the amount of liquidity in the past. The indicator presented here is based on a number of liquidity measures that can be calculated for markets in which the major UK banks are likely to be active (Table 1). However, the final choice of measures was also constrained by data availability. For example, it is difficult to obtain information on volume and bid-ask spreads for instruments that are not traded on a centralised exchange. The measures are grouped into three categories that relate to the academic literature on market liquidity. The first two categories relate to the dimensions of liquidity. Bid-ask spreads are a measure of market 'tightness'. The return to volume ratio is a proxy for market 'depth' and for 'resiliency'; it can be thought of as akin to the slope of the line relating price to quantity in Figure 1. The final category includes estimates for the liquidity premia in financial instruments.

Bid-ask spread

Although bid-ask spreads are used here as an indicator of aggregate liquidity, it is important to note the limitations to this approach. First, bid-ask spreads are generally only quoted for trades of a certain size and so do not necessarily represent the whole market — bid-ask spreads tend to widen for trades that are larger than average.[21] In addition, the bid and ask prices taken from commercial databases, which are often closing prices, will not necessarily represent the actual cost of a trade as buy and sell orders may well be executed at times with different prices. This is clearly more of an issue when measuring bid-ask spreads during periods of high market volatility.

Here bid-ask spreads relative to the mid-price are used, as is common in the academic literature. In markets where the bid-ask spread is positively correlated to the mid-price, the current mid-price is used (equation 1). Otherwise the relative bid-ask spread is calculated using a fixed mid-price (equation 2). This is because the aim is to measure the change in the bid-ask spread due to variations in market-makers' perceptions about expected liquidity, rather than due to changes in the price level.

Table 1: Liquidity measures (raw data source)

Bid-ask spreads	Gilt repo (Bank of England)
	Exchange rates — US dollar with yen, euro and sterling (Bloomberg)
	FTSE 100 — average of individual stocks (Bloomberg)
Return to volume ratio	Gilt market (Bloomberg, Debt Management Office and London Stock Exchange)
	FTSE 100 — average of individual stocks (Bloomberg)
	Equity options — S&P 500 options (Bloomberg and Chicago Board Options Exchange)
Liquidity premia	Corporate bonds — investment grade (Merrill Lynch and Bank of England)
	Corporate bonds — high yield (Merrill Lynch and Bank of England)
	Libor spread — average of three-month US dollar, euro and sterling (Bloomberg)

$$s_t = \frac{a_t - b_t}{\frac{1}{2}(a_t + b_t)}.100 \qquad (1)$$

$$\bar{s}_t = \frac{a_t - b_t}{\frac{1}{2}(a_1 + b_1)}.100 \qquad (2)$$

where, s_t is the current relative bid-ask spread, a_t is the closing ask price, b_t is the closing bid price and a_1 shows the first observation of the ask price.

Return to volume ratio

For a given volume of trading in a market, the greater the absolute return on an asset (or the greater the movement in the asset price) the less liquid the market. Here, the ILLIQ ratio I_t developed by Amihud[22] is used:

$$I_t = \frac{|R_t.100|}{v_t} \qquad (3)$$

where R_t is the asset return and v_t is the volume of trading in that asset. This measure is scaled-up by market capitalisation (ratio of current value to the first observation) to remove the downward trend in the series that is simply due to growth in market size.

The equity market measure is calculated using returns on individual stocks. Data availability constraints mean that the gilt measure uses a generic yield index to calculate asset returns and the equity options measure uses the change in implied volatility in the numerator.

Liquidity premium

As mentioned above, investors will require a liquidity premium for holding a less liquid financial asset. For corporate bonds, the spread of the yield over the relevant risk-free rate is due to: (i) compensation for the credit risk; (ii) compensation for liquidity risk; and (iii) other factors such as regulatory and tax treatment. Given that the last of these is only likely to vary when the regulatory or fiscal regime changes, if the credit spread can be estimated, changes in the residual bond spread are likely to reflect changes in the liquidity of the corporate bond. The credit spread can be estimated from the discounted value of future cash flows, adjusted for the expected default frequency and recovery rate.[23] Here, a type of Merton model is used to derive the last two items from the formula for a barrier option.[24] Figure 2 shows the decomposition for UK high-yield corporate bonds.

A measure of the liquidity premia in the interest rate swap markets is also used. The academic literature has argued that much of the variation in interest rate swap spreads is generally driven by changes in liquidity. The interest rate swap spread essentially compensates investors who, in lieu of purchasing a government bond, enter into a less liquid swap transaction to receive a fixed rate.[25,26] It has been argued that credit

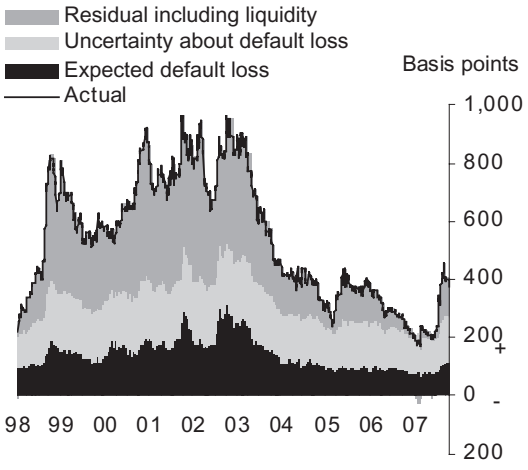

Figure 2: Decomposition of UK high-yield corporate bond spreads
Sources: Merrill Lynch and Bank of England calculations; figure updated to 15th October, 2007.

risk is not normally a significant factor in changes to the interest rate swap spread. This is because the floating leg of the swap, which is usually at Libor, is the interest rate for a loan to AA or AAA-rated banks and this is effectively at a short maturity as the swap is 'refreshed' periodically. As interest swaps can be thought of as a series of forward rate agreements based on Libor, a common proxy for swap spread liquidity in academic papers is the spread between Libor and the treasury bill of the same currency and maturity. This is effectively the spread between the corporate interest rate and a risk-free government interest rate, so should largely reflect liquidity risk, especially over short horizons. In summer 2007, the Libor spread averaged almost 100 basis points, around four times the average over the previous year. Although this reflected both stockpiling of funding and heightened perceptions of counterparty credit risk, the spread was also an indication of a change in the willingness to transact in the inter-bank markets.[27]

Summary indicator

The nine liquidity measures can be summarised into a single composite indicator (Figure 3). This is calculated as the simple average of normalised versions of the composite measures, as follows:

$$L_t = \frac{1}{9} \cdot \sum_{i=1}^{9} \frac{m_t^i - \hat{\mu}^i}{\hat{\sigma}^i} \qquad (4)$$

where L_t is the composite indicator, m_t^i is measure i at time t, $\hat{\mu}^i$ is the sample average of measure i calculated over the period 1999–2004 and $\hat{\sigma}^i$ is the sample standard deviation of measure i over the same period.

The measures are normalised because they are based on different aspects of liquidity and use various units; for example, the FTSE 100 ratio of returns to volume is the percentage of returns per million shares traded, whereas the liquidity premium on investment grade bonds is measured in basis points. The normalisation process allows these measures to be compared with each other and for a summary statistic to be produced. Importantly, because the normalisation is based on a set period, the composite indicator shows an estimate of financial market liquidity relative to that set period.

A simple unweighted average is used. One way of weighting the measures could have been by the importance of the markets for UK banks' trading or hedging activity. This approach is not used here because detailed data on the major UK banks' trading books are not available. Another way of combining the liquidity measures could be to use statistical methods, such as principal components analysis. But, as Figure 4 shows, such a method does not change the qualitative results — the indicator based on principal components analysis has the same general shape as that based on the simple average. In addition, the weights that are derived from the first principal component are not that intuitive: for example, the Libor spread measure is given one of the lowest weights, but inter-bank markets will clearly be important to the UK banking sector. The indicator in Figure 3 is an exponentially weighted moving average of daily data, using a decay factor of 0.94. Although the indicator has daily data back to January 1992, it is more reliable after 1997 as it is based on a greater number of underlying measures

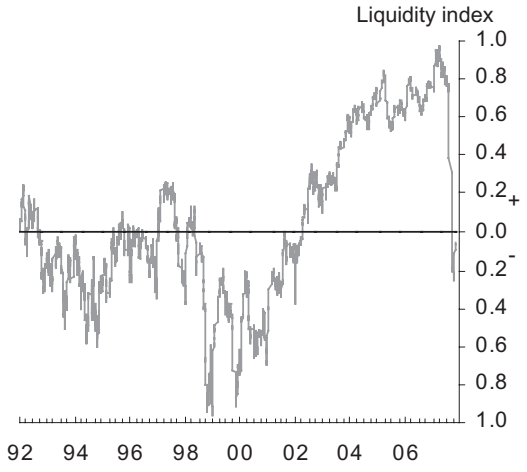

Figure 3: Composite indicator of financial market liquidity
Sources: Bank of England, Bloomberg, Chicago Board Options Exchange, Debt Management Office, London Stock Exchange, Merrill Lynch, Thomson Datastream and Bank of England calculations; figure updated to 15th October, 2007
Note: The liquidity index shows the number of standard deviations from the mean. The indicator is more reliable after 1997 as it is based on a greater number of underlying measures.

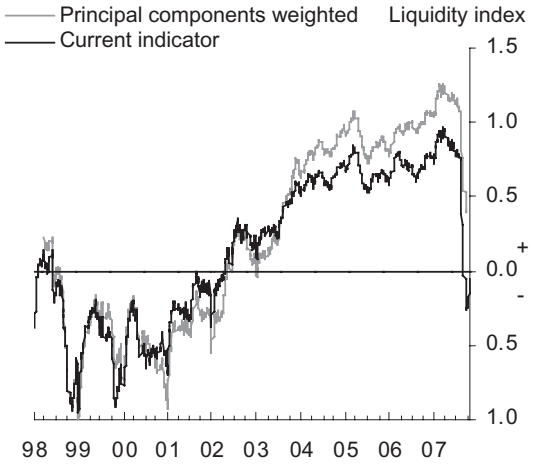

Figure 4: Weighting schemes for the financial market liquidity indicator
Source: Bank of England calculations; figure updated to 15th October, 2007.

(data are not available for a number of these series prior to this point).

The indicator can be thought of as an estimate of the average cost of intermediation in a range of financial markets. The greater this cost, the less liquid financial markets will be. Bid–ask spreads are a direct cost paid by investors trading an asset. The return to volume ratio is a proxy for price 'slippage' and the length of time that this price impact lasts. This deviation in price represents another cost of trading. The liquidity premium on an asset is directly related to the asset's price. If the asset market becomes less liquid, investors will demand greater compensation for holding the asset (the liquidity premium will rise) and so will only be willing to buy the asset at a lower price than previously. Again, this price deviation is another type of trading cost.

IMPLICATIONS

It is difficult to verify the financial market liquidity indicator independently as there is no direct measure of liquidity against which it can be tested. One method is to assess whether the indicator behaves in intuitive ways, particularly during known episodes of illiquidity. Figure 5 shows falls in the liquidity indicator: in 1994 when the Mexican

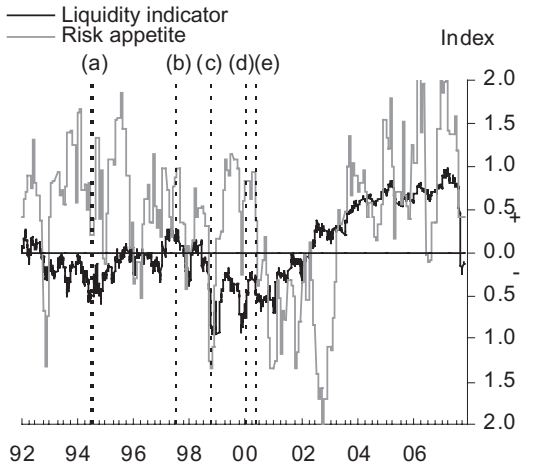

Figure 5: Indicators of liquidity and risk appetite
Sources: Bank of England, Bloomberg, Chicago Board Options Exchange, CSFB, Debt Management Office, London Stock Exchange, Merrill Lynch, Thomson Datastream and Bank of England calculations; figure updated to 15th October, 2007
(a) Mexican peso crisis; (b) start of the Asian crisis; (c) restructuring of LTCM in autumn 1998; (d) turn of the millennium; (e) falls in technology and telecoms stocks.

peso was revalued; during the 1997 Asian crisis; in autumn 1998 following the Russian default; around the turn of the millennium when there were fears about the functioning of IT systems; through 2001 following falls in IT and telecoms stocks; and in summer 2007 at the time of stress in the inter-bank markets.

Another possible approach is to assess the liquidity indicator against data for risk appetite, which is associated with market liquidity. Indeed, the Federal Reserve Board recently defined liquidity as investor confidence.[28] If investors have a strong risk appetite, they will be more willing to trade in financial markets, raising market liquidity. The key problem is that risk appetite is unobservable and any measures are therefore likely to include errors. However, a number of risk appetite measures are produced in the market and Figure 5 plots the average of two such measures, compiled by CSFB and Merrill Lynch, normalised in the same way as the liquidity measures.[29] This shows that, although the risk appetite measures are more volatile than the liquidity indicator, there are a number of periods in which a significant fall in the liquidity indicator coincides with a fall in the average risk appetite measure, for example, in 1994, 1997, autumn 1998, 2001 and in the summer of 2007. Furthermore, the increase in the liquidity indicator from 2003 to mid-2007 is broadly mirrored in the risk appetite measures. It is interesting that, although risk appetite fell sharply towards the end of 2002, during the period of accounting scandals, there was no comparable fall in the aggregate liquidity indicator. This is perhaps because these scandals were most widely felt in the corporate debt markets. Indeed, the liquidity premium component of the indicator, where two of the underlying measures are for the corporate bond market, did fall in this period (Figure 6). Furthermore, there was a fall in the liquidity indicator around the turn of the millennium, but the risk appetite measure was still above average. This may reflect that the concerns about functioning of technology in this period may have reduced market activity, but underlying risk appetite was not significantly impacted.

CONCLUSION

The increase in the liquidity indicator from 2003 may have been caused by a number of factors. First, there were a number of structural changes. New investors, such as hedge funds, have had an increasing role as active players in financial markets and providers of liquidity. Innovation in financial instruments may have helped investors

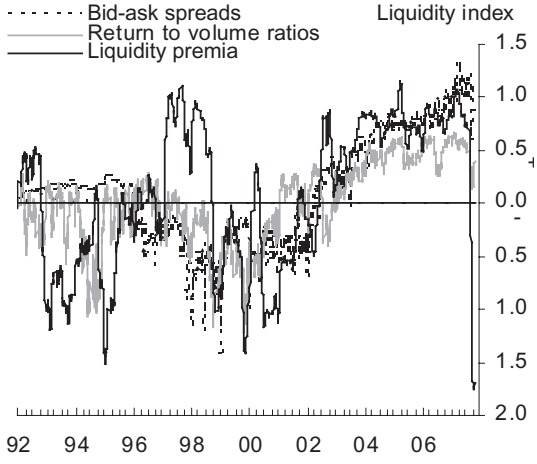

Figure 6: Liquidity measures
Sources: Bank of England, Bloomberg, Chicago Board Options Exchange, Debt Management Office, London Stock Exchange, Merrill Lynch, Thomson Datastream and Bank of England calculations; figure updated to 15th October, 2007
Note: Figure shows the average of the three measures in each category; data shown are an exponentially weighted moving average.

to better match their demands for risk. But the increase in liquidity could have also partly reflected cyclical factors such as the growth in global money supply. The benign macroeconomic conditions, low financial market volatility and increased investor confidence over the period could have also been important. However, the sharp fall in financial market liquidity in the summer of 2007 suggests that short-term factors, such as confidence in the valuation of assets, could be key during periods of stress.

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29 The CSFB Risk Appetite Index seeks to capture fluctuations in market sentiment by looking at risk-adjusted returns of volatile assets versus safe assets. Standard asset pricing relations suggest that such excess returns should be related to risk appetite. The Merrill Lynch Financial Stress Indicator is based on the intuition that higher levels of financial stress would make investors less keen to take on risk.