Liquidity: A Review of Dimensions, Causes, Measures, and Empirical Applications in Real Estate Markets

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Abstract

In this article, we consider how different dimensions of liquidity have been measured in financial markets and for various forms of real estate investment. The purpose of this exercise is to establish the range of liquidity measures that could be used for real estate investments before considering which measures and questions have been investigated so far. Most measures reviewed here are applicable to public real estate, but not all can be applied to private real estate assets or funds. Use of a broader range of liquidity measures could help real estate researchers tackle issues such as quantification of illiquidity premia for the real estate asset class or different types of real estate, and how liquidity differences might be incorporated into portfolio allocation models.

The importance of liquidity and its role in asset pricing are the subject of a vast literature on two main aspects of this phenomenon: trading (or market) liquidity and funding liquidity. Brunnermeier and Pedersen (2009) define these aspects while theoretically conceptualizing and numerically modeling the relation between them. The trading liquidity of an investment is defined as "the ease with which it is traded" while funding liquidity is "the ease with which [investors/traders] can obtain funding" in order to effect its purchase. In this paper, we focus on trading (or market) liquidity and hence the word "liquidity" refers to trading liquidity throughout unless otherwise specified.

Trading liquidity varies between different assets and asset classes owing to a number of market frictions. Where two assets have similar cash flows, but vary in terms of liquidity, investors typically require an additional return, or premium, to invest in the asset with lower liquidity, thus leading to a reduction in its price. This is because lack of liquidity presents a risk/cost of being unable to sell/having to sell at a discount at the specific time when the investor needs to exit. Estimating the existence and magnitude of this premium has been a major topic of empirical investigation in both equity and bond markets, as well as for alternative assets like hedge funds (Sadka, 2010), closed-end funds, and over-the-counter and hard-to-trade securities (Franzoni, Nowak, and Phalipppou, 2012).

Amihud, Mendelson, and Pedersen (2005) summarize studies that theoretically predict and empirically find liquidity to be a statistically and economically significant factor in asset returns even after controlling for risk and asset characteristics. In fact, the introduction of a liquidity factor into asset pricing models improves the explanation of cross-sectional differences in returns, indicating the willingness of investors to pay a premium for more liquid assets, and helps explain some asset pricing puzzles such as the yield differential between on-the-run and off-the-run Treasuries or corporate and government bonds (Longstaff, Mithal, and Neis, 2005; Chen, Lesmond, and Wei, 2007; Bao, Pan, and Wang, 2011). Hibbert et al. (2009) provide a concise summary of seminal papers where liquidity premia are determined either across or within traditional asset classes.

However, liquidity itself is not directly observable and, therefore, proxies must be created to try and estimate relations between this factor and asset prices. Market microstructure and finance researchers have identified several variables that measure different dimensions of liquidity, mirroring a need to capture different facets in either a combined way (e.g., Korajczyk and Sadka, 2008) or separately. Moreover, some studies have shown that mixed results with respect to liquidity premia may arise from the use of different aspects of overall liquidity risk in the analysis (e.g., Baker, 1996; Bertin, Michayluk, Prather, and Kofman (2005). As a consequence, in this paper we evaluate a series of measures that may be helpful for describing real estate liquidity and for comparing results across assets or market segments.

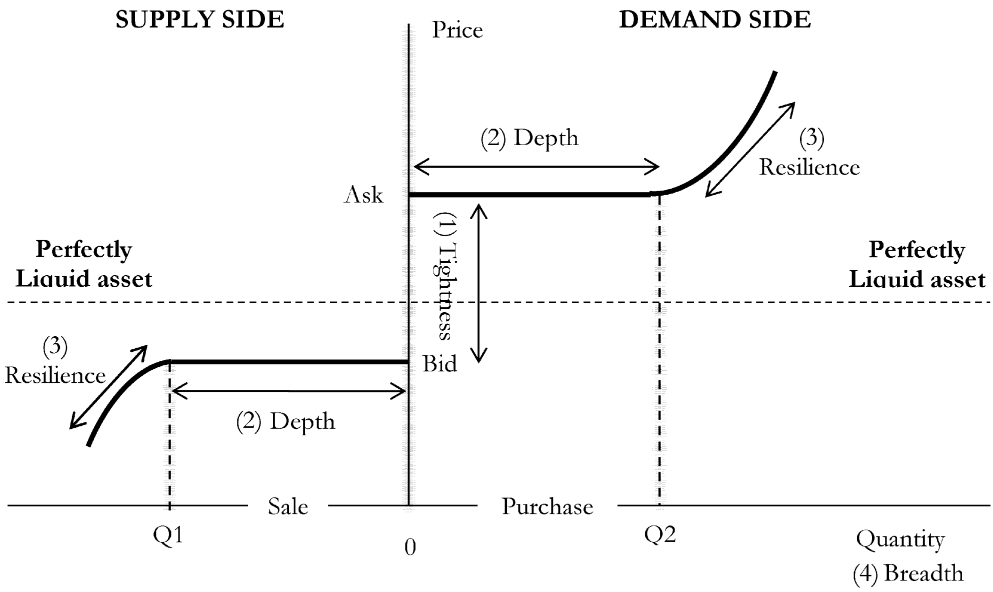
The remainder of this paper is structured as follows. In the next section, we explore the different dimensions of liquidity that have been identified in research, as well as the causes of differences in liquidity between assets. We then review different liquidity measures, classifying them into transaction costs, volume-based measures, price-impact measures, time-based measures, and return-based measures. As we discuss each type of measure, we highlight instances where they have been used in research on either public real estate markets or private real estate funds or assets. We then reflect on some important unresolved questions relating to liquidity and real estate investment that the measures set out in this paper could be used to investigate.

Liquidity Dimensions and Causes

Goodhart (2008) contends that liquidity has many facets. From previous literature, we identify five main characteristics of trading liquidity: (1) Tightness: the cost of trading even in small amounts; (2) Depth: the capacity to sell/buy without causing price movements; (3) Resilience: the speed at which the marginal price impact increases as trading quantities increase; (4) Breadth: the overall size of the volume traded; and (5) Immediacy: the cost (discount/premium) to be applied when selling/buying quickly.

Following Kyle (1985), the first four dimensions are graphically represented in Exhibit 1, as adapted from Kerry (2008) and Hibbert et al. (2009). Here, demand and supply curves, represented as bold curves, can be compared with the one for a perfectly liquid asset (horizontal dotted line) whose price would be constant regardless of the amount of transacted volumes (i.e., no price impact is identified for any volume of trading activity).

Exhibit 1
Dimensions of Market Liquidity



Adapted from Kerry (2008) and Hibbert et al. (2009).

On the demand side, even with a minimum amount of transacted volumes, the buyer must pay a price to enter the transaction (ask price), which is normally above the fundamental price for a perfectly liquid asset. On the opposite end of the trade, the seller must accept to receive a price (bid price), which is below the one of a perfectly liquid asset and the discount represents the illiquidity cost to the seller. The difference between ask and bid is the bid-ask spread. Remaining on the demand curve, if the buyer decides to increase the order flow, initially the marginal impact of such a change (i.e., first derivative of the demand function) is zero and the length of the initial horizontal section of the curve defines the market depth of an asset (the longer the line, the deeper the market). However, after a certain threshold of transacted volumes/ quantities (Q2 in our graph), the marginal impact of an additional unit of trading volume increases and the speed of this continuous increase defines the resiliency of such a market. In other words, for larger quantities of buy orders introduced in a market, the impact on the price is incrementally increasing. The same (but with opposite sign) applies to a seller and the supply function. Initially, the marginal price change is zero. However, beyond a particular threshold of transacted volumes (Q1 in our graph), it decreases incrementally as more sell orders come to market.

If markets were fully efficient, assets would be perfectly liquid and transaction prices would stay on the horizontal dotted line. In other words, assets with similar cash flows should reflect similar valuations. However, some asset/market characteristics may lead to different valuations (and expected returns) for investments with similar cash flows and the main reason is the presence of market imperfections. Following work done by O'Hara (1995) and Hasbrouck (2007) in market microstructure and Amihud, Mendelson, and Pedersen (2005) in asset pricing, Vayanos and Wang (2011) survey the liquidity literature and categorize market imperfections into six groups: participation costs, transaction costs, imperfect competition, asymmetric information, funding constraints, and search costs.

First, participation costs arise because there is no immediate and continuous access to the entire population of counterparties in a trade (i.e., sellers cannot interact with all buyers and vice versa). Hence, agents have to incur a cost to enter the market and this makes them willing to invest only if compensation for this cost is offered in terms of a liquidity premium[1] (Amihud and Mendelson, 1980; Huang and Wang, 2009). Another consequence is the infrequent arrival of agents into the market, with market makers almost obliged to take losses. A clear example of such expenses in real estate markets is represented by the absence for some market segments/products of an active secondary market (e.g., derivative products for small market segments), and the entry of hedge funds and more aggressive players just before and during the most recent economic crisis.

Second, transaction costs refer to the expenses associated with the execution of a trade and can make the effective buying and selling price of the same transaction diverge. A consequence is that assets with transaction costs trade at a lower price in equilibrium (i.e., offer a premium), but this effect can be mitigated by the lengthening of the investment horizon (e.g., Amihud and Mendelson, 1986; Acharya and Pedersen, 2005; Beber, Driessen, and Tuijp, 2012). Examples of transaction costs are taxes and brokerage fees, which are notoriously higher for assets such as real estate. Another clear example is offered by the measure of tightness, which indicates different levels of liquidity in the difference between bid-ask spreads of equity and real estate derivatives (i.e., total return swaps) markets.

Third, asymmetric information can exist because some agents have access to private information or information is obtained from different sources or processed differently. This situation will lead to a liquidity premium when agents want to invest in markets with a high proportion of private information (O'Hara, 2003; Easley and O'Hara, 2004). It can also cause spillover effects in other assets/markets because of information inefficiencies (Cespa and Foucault, 2014). This market imperfection is especially important for assets with scarce and thin information such as real estate, where we can observe a greater difference between offer prices than for publicly traded equities or bonds.

Fourth, imperfect competition is linked to the scale of different market players and hence their asymmetric impact on prices either due to their size or information advantage. Seminal works in this area are Kyle (1985, 1989)—who shows the dynamics of risk sharing—see also DeMarzo and Urosevic (2006), Brunnermeier and Pedersen (2005)—and the conditions for market failure—Glosten (1989). They have been further extended to incorporate different speeds of information revelation caused by risk-averse agents (Baruch, 2002), insiders (Chau and Vayanos, 2008), and the presence of regulation (Huddart, Hughes, and Levine, 2001). The issue of imperfect competition is even more important for heterogeneous and non-divisible goods like private real estate assets. For example, small investors cannot easily obtain information about asset payoffs and they do not have access to some investment opportunities because of diversification issues caused by the size of these investments relative to other assets in the portfolio (Fuerst and Marcato, 2009).

Fifth, funding constraints do not allow agents to borrow freely, restricting their capacity to invest in some markets or segments. This phenomenon may be linked to the uncertainty attached to the liquidation value (Shleifer and Vishny, 1992; Hart and Moore, 1994, 1995) and limits to financing applied on intermediaries offering liquidity (Gromb and Vayanos, 2002; Liu and Longstaff (2004). Furthermore, a possible contagion (or spiral) effect is found for assets that would be otherwise unrelated, as we have seen during the most recent financial crisis (Brunnermeier and Pedersen, 2009), especially for agents with a short investment horizon (Shleifer and Vishny, 1997) and even for optimal contracts (Acharya and Viswanathan, 2011). Funding constraints are probably the one market imperfection that interacts most with all other imperfections. Hence, Krishnamurthy (2010) and Albagli (2011), among others, have focused on this interaction to tease out plausible amplifying effects.

Sixth, search costs arise from a decentralized form of organization—the normal way that over-the-counter (OTC) markets operate—and they are associated with the need to find a counterparty (Duffie, Garleanu, and Pedersen, 2002, 2005, 2007; Vayanos and Wang, 2007). This market imperfection is particularly applicable to private real estate and unlisted financial products based on those assets (e.g., real estate derivatives and unlisted funds). A vast literature on this aspect of liquidity has developed for the residential sector.

As we have seen, there are several factors that arise from the imperfect structure of investment markets and cause differences in liquidity to emerge between individual assets and groups. Yet, while it is usually possible to identify the presence of such factors, several are difficult to quantify directly, transaction costs being the most obvious exception. Therefore, many empirical measures of liquidity diverge from the factors listed above, but still have the aim of representing one or more of the dimensions of liquidity highlighted at the outset of this section.

MEASURES OF LIQUIDITY

We now seek to examine some of the main empirical indicators of liquidity, grouping these into five main categories: (1) transaction costs, (2) volume-based measures, (3) price impact, (4) time-based measures, and (5) return-based measures. Our classification is analogous to that of Sarr and Lybek (2002), but we extend it by separating out return-based measures and adding time-based measures, with the latter used extensively for real estate assets.

TRANSACTION COSTS

While transaction costs encompass a range of fees and taxes that an investor must pay to execute a trade, much attention is paid to bid-ask spreads in the finance

Exhibit 2
Transaction Cost Measures of Liquidity

Liquidity Measure	Proxy	Formula/Model	Liquidity Dimension	Private Real Estate[a]
Absolute Quoted Spread	I	$Sabs_t = p_t^A - p_t^B$	(1)	No
	I	$LogSabs_t = \ln(p_t^A - p_t^B)$	(1)	No
Relative Quoted Spread (or "inside spread")	I	$Srel\_mid_t = \frac{(p_t^A - p_t^B)}{p_t^M}$	(1)	Yes (U.S.)
	I	$Srel\_last_t = \frac{p_t^A - p_t^B}{p_t}$	(1)	No
Effective Spread	I	$Seff_t = \lvert p_t - p_t^M \rvert$	(1)	No
Relative Effective Spread	I	$Sreleff\_mid_t = \frac{\lvert p_t - p_t^M \rvert}{p_t^M}$	(1)	No
	I	$Sreleff\_last_t = \frac{\lvert p_t - p_t^M \rvert}{p_t}$	(1)	No

Notes: Legend: Proxy L = liquidity measure; Proxy I = illiquidity measure; p_t^A = lowest ask price; p_t^B = highest bid price; p_t = last traded price before time t; p_t^M = mid-quote price, obtained as $p_t^M = (p_t^A + p_t^B)/2$. (1) Tightness; (2) Depth; (3) Resilience; (4) Breadth; and (5) Immediacy.
[a] All measures could be applied to public real estate investments.

literature. Demsetz (1968) initiated empirical research on bid-ask spreads and many studies follow from this ground-breaking work. For example, Corwin (1999) and Chordia, Roll, and Subrahmanyam (2001) study stocks traded in the New York Stock Exchange, Christie and Schultz (1994) and Barclay et al. (1999) examine the NASDAQ, and Grammig, Schiereck, and Theissen (2001) study stocks in the German market. Meanwhile, Acker, Stalker, and Tonks (2002) analyze the behavior of bid-ask spreads around corporate earnings announcement dates and Harris, McInish, and Wood (2002) explore price discovery mechanisms by comparing trading patterns in different stock exchanges.

Different bid-ask spread measures are set out in Exhibit 2. We report the liquidity measures in the first column, an indication of whether the measure is a proxy for liquidity (L) or illiquidity (I) in the second column, and the formula or model to compute it in the third column. The liquidity dimension(s) captured by each measure and their use in research on private real estate markets are shown in the last two columns (a similar format is used in subsequent tables).

In absolute form, the bid-ask spread represents the difference between the lowest price at which a stock or instrument can be obtained from a seller (ask) and the highest price at which it can be sold to a buyer (bid). An asset is more illiquid when the spread is large. This measure is always positive and its lower boundary is the minimum tick size. While for small orders, the quoted absolute spread is a good proxy for the execution costs of a trade, other costs may need to be added for larger orders. Some researchers such as Hamao and Hasbrouck (1995) use a logarithmic version of the absolute spread to improve its distributional properties.

However, the relative spread (sometimes termed "inside spread") represents the most extensively used measure of illiquidity since it allows comparison between stocks with different stock prices. It can be computed as a percentage of the last traded price or the middle price (average of bid and ask prices), the advantage of the latter being the possibility of computing it even when no trades take place.

Grossman and Miller (1988) and Lee, Mucklow, and Ready (1993) document that a large number of transactions take place at prices outside the bid-ask range and so the quoted spread seems to be too noisy. As a result, the effective spread is found to better represent the round-trip costs of an order. This measure includes price movements (dealers execute orders at prices better than previously quoted) and market impact (where the spread is widening due to the order size). It is computed as the absolute difference between the last traded price and the middle price. If this measure is smaller than half the absolute spread, trading is happening within quotes. The effective spread is normally multiplied by two to make it comparable to other spread measures (Lin, Sanger, and Booth, 1995; Bacidore, 1997; Jones and Lipson, 1999; Bacidore, Battalio, and Jennings, 2002) and sometimes weighted with trade size (or number of trades) to obtain an average effective spread over a period of time (Lee, Mucklow, and Ready, 1993). A liquidity premium can also be estimated as in Battalio, Greene, and Jennings, (1998), who compute it as $LP_t = I \cdot (p_t - p^t_m)$, where I is the direction of trade indicator (equal to 1 and -1 for trades initiated respectively by buyers and sellers) and the premium is positive if the buyer pays more than the spread midpoint. Finally, the relative effective spread can be computed by dividing the effective spread by either the last trade price or the mid-price. The relative version of the measure facilitates comparability across securities.

Frequent use of spreads to study the liquidity of stocks has led them to be analyzed in studies of listed real estate equities. Generally, liquidity has improved over time both in the 1990s (Bhasin, Cole, and Kiely, 1997) and 2000s (Marcato and Ward, 2007), with differences in the pattern of its components (Clayton and MacKinnon, 2002) and between stock exchanges (e.g., NYSE and NASDAQ) where securities are traded (Danielsen and Harrison, 2000). Bid-ask spreads are also observable for certain types of private real estate vehicles, such as open-ended funds. However, spreads for private real estate assets are not available. Given the differences in trading mechanisms between stock markets and private real estate markets, there is no direct equivalent of the bid-ask spread in the latter case. In the residential real estate literature, Jud, Winkler, and Kissling (1995) advocated the difference between list price and contract price as a liquidity measure for both housing markets and assets. In strong markets, though, contract prices can rise above list prices (Haurin et al., 2013), which does not conform to conventional notions of a bid-ask spread.

VOLUME-BASED MEASURES

Volume-based measures distinguish liquid markets either by the absolute or relative amount of transactions to understand the breadth and depth of a market or asset. As Exhibit 3 shows, they can be constructed with reference either to the number of assets traded or the amount of capital spent in transactions.

Exhibit 3
Volume-based Measures of Liquidity

Liquidity Measure	Proxy	Formula/Model	Liquidity Dimension	Private Real Estate[a]
Transaction Volume	L	$Vol_t = \sum_{i=1}^{n} P_{it} Q_{it}$	(4)	Yes
Turnover Ratio	L	$Turn_n = \frac{Vol_t}{(S_t * P_t)}$	(4)	Yes
Quote Size	L	$QS = \frac{Ave\ No\ of\ Transactions}{Ave\ Size\ of\ the\ Market}$	(2)	~Yes
Number of Bids	L	No. (or log) of individual bids	(4)	~Yes
Market Depth	L	$Depth = q_t^A + q_t^B$	(2)	No
	L	$Log\ Depth = ln(q_t^A + q_t^B)$	(2)	No

Notes: Proxy L = liquidity measure; Proxy I = illiquidity measure; TR_i = total return of an asset/market on the day i of month t; Vol_i = transaction volume of an asset/market on the day i of month t; Z_{jt} and δ_j = j control variables and their estimated coefficients; $r_{i,d,t}$ = return of asset i in day d of the month t; $r^e_{i,d,t}$ = same return but in excess of the market return; $sign(.) * Vol_{i,d,t}$ = signed transaction volumes; T_t = number of trading days in a month t; $NR_{i,t}$ = number of zero-return days in month t; $NV_{i,t}$ = number of zero-volume days in month t; $Var(R_t)$ = variance of long-period returns; $Var(r_t)$ = variance of short-period returns; p = number of short periods within each long period. (1) Tightness; (2) Depth; (3) Resilience; (4) Breadth; and (5) Immediacy.
[a] All measures could be applied to public real estate investments.

The simplest measure in this category is transaction volume as measured by the total number or value of trades over a given time interval. Although it is an indirect measure of liquidity, its popularity derives from empirical evidence that more active markets tend to be more liquid, and from theoretical studies linking increased trading activity with improved liquidity through ease of access and decrease in transaction costs. Furthermore, it is widely available, as volume figures are regularly reported for most assets. However, a drawback is its association with market volatility, which may reduce market liquidity (Karpoff, 1987). For example, Jones, Kaul, and Lipson (1994) find a positive relation between volatility and number of trades, with trade size containing little information.

A related measure is turnover, which scales transaction volumes to the size of the asset or market concerned. In the case of divisible assets, it represents a proxy for the number of times that the outstanding volume of an asset is transacted within a specified time period. While its computation is easy for exchange-traded securities, adequate coverage of transaction volumes and estimation of existing stocks represent critical issues for OTC assets and real estate. Amihud and Mendelson (1986) show that turnover is negatively correlated with illiquidity costs. In fact, when the turnover ratio is low, market makers tend to charge a higher transaction cost to cover the risk of holding their position, so the higher the turnover ratio, the more liquid the asset/market.

Turnover has been a popular liquidity measure in previous literature (Rouwenhorst, 1999; Chordia and Swaminathan, 2000; Dennis and Strickland, 2003). The theoretical motivation for using turnover as a liquidity proxy goes back to Demsetz (1968), who shows that the price of immediacy would be smaller for stocks with high trading frequency since frequent trading reduces the cost of inventory controlling. Glosten and Milgrom (1985) show that shares with high trading volumes have lower levels of information asymmetry to the extent that information is revealed by prices. Finally, Constantinides (1986) finds that investors will increase their holding periods (reducing turnover) when a stock is highly illiquid.

Another volume-based measure is quote size, which is often studied alongside bid-ask spreads. It represents a proxy for market depth and refers to the quantity of securities tradable at the bid and ask prices (Mann and Ramanlal, 1996). As market makers do not necessarily reveal the full amounts they are willing to trade at the stated prices, the measured depth may underestimate the true depth. Therefore, a related measure is the quantity of securities that are traded at the bid and ask prices. A drawback of this measure is the limited availability of such information because market makers may not reveal this amount. It can also underestimate market depth because the quantity actually traded does not necessarily reflect the amount that could have been traded at a given price.

Quantity or volume depth is computed as the sum of bid and ask volumes at time t (e.g., Huberman and Halka, 2001; Brockman and Chung, 2002). Several researchers employ this measure to assess the premium of specific assets or link it to abnormal trading (e.g., Corwin, 1999; Greene and Smart, 1999; Corwin and Lipson, 2000). To improve the distributional properties of this measure, a logarithmic transformation is also used (Butler, Grullon, and Weston, 2005). As the market depth for bid and ask can be computed separately, the overall depth can be obtained as an average of the two (Goldstein and Kavajecz, 2000; Chordia, Roll, and Subrahmanyam, 2001). As depth measures of bid and ask prices of the limit order book are not symmetrical and do not necessarily move together, the computation of separate measures may also be helpful to study liquidity (Kavajecz, 1999; Kavajecz and Odders-White, 2001).

As far as real estate markets are concerned, several researchers use trading volumes and turnover to test the presence of pricing signals (with price movements following trading activity) and/or return chasing behavior (with investors induced to trade by price movements). Particularly, Fisher, Ling, and Naranjo (2009) and Ling, Marcato, and McAllister (2009) analyze private real estate markets respectively in the United States and United Kingdom, while Marcato and Ward (2007) and Marcato and Tira (2015) shed light on listed and unlisted real estate vehicles, respectively.

Finally, trading should be easier when there are a greater number of bids as sellers have a higher likelihood of finding counterparties. Kleymenova, Talmor, and Vasvari (2012) use the number of bids to gauge the liquidity of private equity funds. They compute the logarithm of the number of individual spot or portfolio bids received for a particular fund and they also measure the dispersion in bids received during the first round of bidding. The number of bidders could be a relevant liquidity proxy in a

Exhibit 4
Price Impact Measures of Liquidity

Liquidity Measure	Proxy	Formula/Model	Liquidity Dimension	Private Real Estate[a]
Amihud Measure	I	$Amihud_t = \frac{1}{n}\sum_{i=1}^{n}\frac{\lvert TR_i\rvert}{Vol_i}$	(2, 3)	~Yes
Regressed Lambda	I	$TR_t = \alpha + \lambda Vol_t + \sum_{j}^{m} \delta_j * Z_{jt}$	(2, 3)	Yes
Pastor-Stambaugh Liquidity Factor	I	$r^e_{i,d+1,t} = \theta_{i,t} + \omega_{i,t} r_{i,d,t} + \gamma_{i,t} sign(r^e_{i,d,t}) * Vol_{i,d,t} + \epsilon_{i,d+1,t}$	(2, 3)	Yes
Percentage of Zero Returns	I	$ZR_{i,t} = \frac{NR_{i,t}}{T_t}$	(2)	Yes
Percentage of Zero Volumes	I	$ZV_{i,t} = \frac{NV_{i,t}}{T_t}$	(2)	~Yes
Market Efficiency Coefficient	I	$MEC = \frac{Var(R_t)}{(p * Var(r_t))}$	(3)	Yes

Notes: Proxy L = liquidity measure; Proxy I = illiquidity measure; TR_i = total return of an asset/market on the day i of month t; Vol_i = transaction volume of an asset/market on the day i of month t; Z_{jt} and δ_j = j control variables and their estimated coefficients; $r_{i,d,t}$ = return of asset i in day d of the month t; $r^e_{i,d,t}$ = same return but in excess of the market return; $sign(.) * Vol_{i,d,t}$ = signed transaction volumes; T_t = number of trading days in a month t; $NR_{i,t}$ = number of zero-return days in month t; $NV_{i,t}$ = number of zero-volume days in month t; $Var(R_t)$ = variance of long-period returns; $Var(r_t)$ = variance of short-period returns; p = number of short periods within each long period. (1) Tightness; (2) Depth; (3) Resilience; (4) Breadth; and (5) Immediacy.

[a] All measures could be applied to public real estate investments.

private real estate context if adequate data on bidding activity were to be compiled. Similarly, the number of dealers is used as a liquidity proxy in corporate bond markets (Houweling, Mentink, and Vorst, 2005; Jankowitsch, Mösenbacher, and Pichler, 2006).

PRICE IMPACT MEASURES

Price impact measures, formulas for which are reported in Exhibit 4, intend to separate liquidity from other factors, such as general market conditions or arrival of new information driving price movements. Bernstein (1987) argues that liquidity should be more relevant for securities when there is no information revelation than when new information processing leads to a new equilibrium.

The Amihud (2002) measure identifies the price impact of transaction volumes and is frequently used in long-term studies (Avramov, Chordia, and Goya, 2006; Watanabe and Watanabe, 2008; Karolyi, Lee, and Van Dijk, 2012). In equity markets, it is computed at a monthly frequency using daily data and it is found to correlate with bid-ask spreads. An alternative but similar illiquidity measure is represented by the regression coefficient of returns on the volume of transaction activities (also known as regressed lambda), which represents the price impact per unit of trade due to the existence of market imperfections.

Pastor and Stambaugh (2003) propose a monthly liquidity measure obtained using daily data within each month and computed for a market as the equally-weighted average of liquidity measures for single assets/securities. This proxy is computed as the coefficient of the signed transaction volume regressed on excess returns. It is linked to the idea that the signed transaction volume should lead to an expectation of reversal in future returns. Hence, the estimated value should be negative and increasing in absolute value for assets/periods with higher illiquidity.

Lesmond, Ogden, and Trzcinka (1999) developed a model to estimate transaction costs from time series of daily stock returns, assuming that days of zero return should be observed when the expected return does not exceed the transaction cost, which is set as a threshold. Hence, the likely relation between days of high transaction costs and days of zero return should be coupled with a relatively small incentive for investors to gain private information for assets with high transaction costs. As a result, most trades are noisy and so should lead to zero-return days with volumes still likely to be positive. At a monthly frequency, the measure would be computed as the number of zero-return days in each period divided by the number of trading days.

In emerging markets, Lesmond (2005) and Bekaert, Harvey, and Lundblad (2007) find that this measure is highly correlated with other traditional measures of transaction costs. Using trade and quote (TAQ) data, Goyenko, Holden, Lundblad, and Trzcinka (2005) find similar patterns between transaction costs obtained with high frequency data and the measure of zero return days in the U.S. market. Finally, Goyenko, Holden, and Trzcinka (2009) suggest an alternative and restricted version of the original measure, arguing that zero returns in periods with no transaction volumes do not contain any new information and so do not represent an adequate proxy for illiquidity. Therefore, they compute the proportion of days with positive trading volume but zero return (i.e., eliminating the days with zero returns and zero volumes). Since highly illiquid assets are transacted less frequently and hence are more likely to report days with a zero trading volume, Kang and Zhang (2014) suggest another proxy: the proportion of days with zero trading volumes within the interval.

Furthermore, the market efficiency coefficient (MEC), or variance ratio, was developed by Hasbrouck and Schwartz (1988) and is used extensively in the finance literature. For a given permanent price movement, the transitory shifts to that price tend to be minor in resilient markets. Hence, the ratio tends to be close but slightly below one in more resilient markets because a minimum threshold of short-term volatility should be expected in such an environment. In contrast, in markets with low resiliency, we should expect higher short-term volatility due to overshooting and hence a greater number of transitory changes between periods with different equilibrium prices. Spreads, price rounding, and inaccurate pricing mechanisms including partial adjustment to new information represent some of the factors reducing the MEC significantly below one (Sarr and Lybek, 2002).

Finally, price impact measures are not widely used in the real estate literature. Some examples for listed real estate securities and private real estate are offered respectively by Brounen, Eichholtz, and Ling (2009) and Marcato (2015).

Exhibit 5
Time-based Measures of Liquidity

Liquidity Measure	Proxy	Formula/Model	Liquidity Dimension	Private Real Estate[a]
Holding Periods	I	$HP = \frac{(S_t * P_t)}{Vol_t} = \frac{1}{Turn_n}$	(4)	Yes
Trading Frequency	L	$WT_t = \frac{1}{N = 1} \sum_{i=2}^{N} tr_i - tr_{i-1}$	(2)	~Yes
Volumes Volatility	I	$\sigma_{Vol_t} = \frac{\Sigma\ Vol_t - \overline{Vol_t}}{N - 1}$	(2, 4)	Yes
Time-on-the-Market	I	Time required to transact	(5)	Yes

Notes: Proxy L = liquidity measure; Proxy I = illiquidity measure; S_t = number of outstanding stocks; P_t = average price of the i trades included in transaction volumes; Vol_i = transaction volume of an asset/market on the day i of month t; tr_i = denotes the time of the trade at time t. (1) Tightness; (2) Depth; (3) Resilience; (4) Breadth; and (5) Immediacy.
[a]All measures could be applied to public real estate investments.

TIME-BASED MEASURES

Time-based liquidity measures capture either the time that has elapsed between transactions or the time required to trade an asset once a decision to buy or sell is made. See Exhibit 5 for a list.

Asset pricing models normally include market frictions assuming the presence of exogenous transaction costs, and the effect of such costs increases in proportion to the trading frequency of investors. Thus, the magnitude of transaction costs may influence expected holding periods, whereby markets/assets associated with higher trading costs such as private real estate exhibit longer holding periods (Collett, Lizieri, and Ward, 2003). Data on holding periods is not easily available and may necessitate the analysis of private datasets [e.g., for real estate, see Fisher and Young (2000)]. An indirect measure of holding periods is the inverse of the turnover rate. However, while investments with high turnover may have many actively trading investors, not all investors necessarily have short holding periods because high turnover may be caused by a few very actively engaged traders. In contrast, the actual holding period for an asset held by an investor would simply be the time between the purchase and sale dates.

Trading frequency is another time-based measure closely related to trading volume. It represents the number of trades executed within a specified interval disregarding the trade size. To obtain trading frequency, a count of the number of trades is required. Information on the timing of transactions may also be used to compute the average waiting time between two consecutive trades, as studied by Peng (2001). High trading frequency can be associated with liquid assets/markets, but it can also be linked to an asset/market with high price volatility and low liquidity as well, mirroring the case of volumes.

Meanwhile, for assets that are not typically divisible and not traded frequently, such as private real estate, a related proxy for liquidity is the volatility of transaction volumes. This should be inversely proportional to the trading frequency and the implication of this measure can be twofold: that the average trading volume is lower (and hence similar swings show higher impact) and/or the swings in transaction volumes from one period to the next (i.e., volumes volatility) are higher. Although this measure should have relevance to private real estate markets, we are not aware of any studies to date that make use of this measure.

If an asset is traded more often, it is considered more liquid. However, there could be instances where assets are held for a long period because they have particularly desirable characteristics and not because they are difficult or costly to trade (certain types of real estate or trophy buildings may be examples). In this case, transacting such assets should happen quickly once they are marketed. In mainstream financial markets, this time may often seem trivial in length owing to the existence of centralized public exchanges. Nonetheless, the time to execute trades can still be of importance. For instance, certain arbitrage strategies may need to be executed within minutes or even seconds, and so the possibility of being able to trade within such intervals becomes important.

For residential real estate markets, the time taken to transact (or time-on-the-market) has been studied extensively. Sirmans, MacDonald, and Macpherson (2010) provide a meta-analysis of some of the most important studies, while Benefield, Cain, and Johnson (2014) review research that tests how time-on-the-market and real estate prices are related. The reason for such interest in the time taken to transact lies in the decentralized nature of real estate markets, which requires search for appropriate assets and/or willing counterparties, and the physical, legal, and spatial heterogeneity of houses, which necessitates extensive due diligence by purchasers. As a result, time-on-the-market is both non-trivial and uncertain. Although this is true for commercial real estate as well, there is far less literature on time-on-the-market in comparison, despite the implications for investors.

The uncertainty surrounding the time needed to transact is discussed from a seller perspective by Lin and Vandell (2007). They provide a description of the real estate sale process in which a defining feature is the sequential but random arrival of offers that characterizes the outcome of search by both buyers (for assets) and sellers (for counterparties). During the marketing period, buyers make offers based on information acquired during their search. Each time a buyer makes an offer, the seller evaluates the benefits of waiting for a potentially better offer and the costs associated with waiting before deciding whether to sell. If a price is agreed, the marketing period ends, but, if agreement is not reached, the search by each party continues, so both price and the timing of its receipt remain uncertain until the transaction process is concluded.

Another issue surrounds how time to transact is defined and measured. First, studies usually focus on time-on-the-market from a seller perspective, even though the buyer perspective (market entry) also matters. Second, time-on-the-market is typically defined as starting from the date when a property is advertised for sale, but this

Exhibit 6
Return-based Measures of Liquidity

Liquidity Measure	Proxy	Formula/Model	Liquidity Dimension	Private Real Estate[a]
Roll Measure	I	$\begin{cases} 2 \times \sqrt{-cov(\Delta P_t, \Delta P_{t-1})} & \text{if } cov < 0 \\ 0 & \text{if } cov \geq 0 \end{cases}$	(3)	~Yes
Run-Length	I	$RL_{i,m} = \frac{N^{run}}{N_m}$	(2, 3)	Yes

Notes: Proxy L = liquidity measure; Proxy I = illiquidity measure; P_t = average price of the *i* trades included in transaction volumes; N^{run} = sum of the length of each run in a month *m*; N_m = number of runs in a month *m*. (1) Tightness; (2) Depth; (3) Resilience; (4) Breadth; and (5) Immediacy.
[a] All measures could be applied to public real estate investments.

excludes the time needed to prepare an asset for sale. The end point for measurement is also ambiguous: should it be the date of price agreement, contract exchange or formal completion?

Benefield and Hardin (2015) highlight a lack of attention to the definition of time-on-the-market in the residential real estate literature. In contrast, some researchers have debated the different stages involved with trading commercial real estate assets. McNamara (1998) breaks the sales process in the U.K. into three periods: (1) until an agreement on heads of terms is reached; (2) between agreement and exchange of contracts; and (3) between exchange and money transfer. IPF (2004) dissects these stages further. Arguably, all three periods affect liquidity risk, although the agreed price should not change during the third of these periods.

RETURN-BASED MEASURES

Some liquidity indicators are drawn theoretically from the impact that a lack of trading activity may have on price movements and hence the properties of return time series. These measures have become popular because return indices exist for many assets and markets, and no additional information is required. See Exhibit 6 for computation.

Roll (1984) developed an implicit measure of the effective bid-ask spread using the serial covariance of share prices whereby an illiquid asset should show a stronger autocorrelation pattern. With the probability distribution of returns assumed to be stationary and the market to have informational efficiency, the price of an asset is modeled as the sum of its unobserved fundamental value and half of the effective spread plus a buy/sell indicator for the last trade. If we reasonably assume that the buy/sell indicator is serially uncorrelated and dependent on public information shocks, an effective spread can also be estimated as a function of the autocorrelation pattern of the series. The Roll measure is useful because daily prices are enough to estimate it, but it does not seem to have a meaningful interpretation when the sample serial covariance is positive, a normal stylized fact in markets with lower levels of market efficiency, such as emerging markets and real estate. As a result, Goyenko, Holden, and Trzcinka (2009) present a modified Roll measure where zeros replace observations with positive covariances. Moreover, a modified Roll measure for real estate markets is presented in Marcato (2015), who finds evidence of a liquidity premium varying over time.

Meanwhile, Das and Hanouna (2010) developed an illiquidity proxy based on run length of returns, defined as the consecutive series of positive or negative returns without reversion. Empirically, they showed that run lengths are positively related to the price impact of trading and can explain cross-sectional variation of stock returns.

Studies on Real Estate Liquidity

After identifying the dimensions and causes of liquidity and introducing measures that can proxy for this risk, we discuss empirical research related to real estate markets/products. We begin by reviewing studies that explore public real estate before turning to the private real estate market and finally to work produced on unlisted real estate vehicles.

EMPIRICAL EVIDENCE IN PUBLIC REAL ESTATE

Corgel, McIntosh, and Ott (1995), Zietz, Sirmans, and Friday (2003), and Feng, Price, and Sirmans (2011) provide descriptive overviews of exchange-listed REITs. The liquidity of REITs relative to alternative investments linked to real estate has great appeal and this allowed the market to develop with a high institutional component in its ownership structure.

Nelling, Mahoney, Hildebrand, and Goldstein (1995) find that the liquidity of real estate investment trusts (REITs)—daily closing bid-ask spread for securities listed in the NASDAQ—decreased during 1980s, making these products relatively expensive over that period. Following this work, but using market microstructure data, Bhasin, Cole, and Kiely (1997) show that, during mid-1990s, the trend inverted and these products became more liquid, partly thanks to a significant growth in their number and market capitalization driven by the "new REITs era" (Cole, 1998). Bhasin, Cole, and Kiely (1997) use an empirical model of spreads following Stoll (1978) and shed light on their determinants: price and dollar volume (positive relation) and return volatility (negative). Clayton and MacKinnon (2000) confirm these results for the early 1990s by decomposing the percentage spread into three components (depth, tightness and resiliency) following Kyle (1985) and find that most gains are driven by improvements in depth rather than tightness. Meanwhile, Cannon and Cole (2011) find significant improvements in the overall liquidity of REITs around 2000–2006.

Marcato and Ward (2007) develop the model in Clayton and MacKinnon (2000) to allow an estimation with daily rather than intra-day data. Similar results are found for the U.S., with improving liquidity measured for both estimated spreads and market depth. The choice of stock exchange is found to be significant, with even smaller REITs benefiting from listing in the NYSE as opposed to NASDAQ and AMEX, similar to Danielsen and Harrison (2000), who found the NYSE and AMEX to be preferable to the NASDAQ. Weaker results are also found for other markets (U.K. and Australia).

Characterizing the intraday-trading behavior, Below, Kiely, and McIntosh (1995) find that (1) REIT structures present a smaller amount of volumes and trades than non-REIT ones, (2) equity REITs present higher spreads than mortgage REITs, and (3) REITs with high institutional ownership trade at spread levels similar to those observed for non-REITs. However, Bertin, Michayluk, Prather, and Kofman (2005) argue that using raw spreads fails to include transactions taking place inside the quoted spread. Therefore, they compute several liquidity proxies and show that REIT liquidity follows an intraday U-shaped pattern similar to that of common stocks.

Brounen, Eichholtz, and Ling (2009) support the idea of studying several dimensions of liquidity in international markets and use three proxies for liquidity—dollar trading volume, turnover, and a version of the Amihud measure—to avoid misleading conclusions. They show that dividend yield, market capitalization, and non-retail share ownership are the main drivers of liquidity. Furthermore, Subrahmanyam (2007) finds liquidity risk to be priced in REITs. He is the first to explore order flow spillovers across NYSE stocks, finding that this phenomenon occurs from REITs to non-REITs and that liquidity measures of the latter are a good predictor for the former.

Benveniste, Capozza, and Seguin (2001) compare asset replacement value with company value and show that the securitization process of assets obtained through the REIT structure enhances the underlying asset value by 10%–20%. Yet, they do not find that the market value of equity provides explanatory power for liquidity when they include control variables such as sector and institutional ownership. Following from the evidence that REITs partly reflect equity and partly private real estate performance, Bond and Chang (2012) study the cross-asset liquidity between these three markets/assets. In line with theoretical expectations, they find liquidity risk and commonality in liquidity to be generally lower for REITs than for other equities and causality going from public to private markets.

Finally, a recent study by Glascock and Lu-Andrews (2014) sheds light on the macroeconomic factors driving REIT funding liquidity and its linkages with market liquidity across the business cycle. The authors use the Amihud measure and turnover ratio for market liquidity and LTV ratio, debt service coverage ratio, and number of loans for funding liquidity. This study shows that both contemporaneous and lagged macroeconomic factors have a significant impact on REIT funding liquidity; negative for inflation, default spreads, and term spreads and positive for the banks' willingness to lend.

EMPIRICAL EVIDENCE IN PRIVATE REAL ESTATE

There are fewer studies of liquidity for private real estate than for either financial assets or REITs. In part, this stems from the decentralized and private nature of real estate markets that has created difficulties in obtaining data and creating liquidity measures. Yet, liquidity issues have been subject to more extensive study in recent years, including work that considers the impact of liquidity on real estate price series.

This has resulted in the creation of liquidity indices in the U.S., although the assumptions and models required to produce such indices are methodologically complex. Meanwhile, other research has occurred using more traditional liquidity indicators such as volumes and time-on-the-market.

Fisher, Ling, and Naranjo (2009) and Ling, Marcato, and McAllister (2009) have explored the relation between volumes and returns in private real estate investment markets. They examine the relation between capital flows and investment returns in the U.S. and the U.K., respectively, to see whether they affect each other. Both studies use a vector autoregressive (VAR) approach where institutional capital flows and returns are specified as endogenous variables in a two-equation system. Fisher, Ling, and Naranjo (2009) find that lagged capital flows have a statistically and economically significant relationship with returns, which suggests weight-of-money effects in pricing. They do not find evidence for return chasing. Ling, Marcato, and McAllister (2009) find positive contemporaneous correlations between returns, absolute and percentage capital flows, and turnover, but their results did not support the idea that capital flows exert a ‘‘price pressure’’ effect in the U.K.

The composition of transaction volumes is studied in Fisher, Gatzlaff, Geltner, and Haurin (2004). They examined sales out of the population of private real estate investments monitored by the National Council of Real Estate Investment Fiduciaries (NCREIF) in the U.S. They tested whether specific property, owner or market characteristics affected the probability of an asset being sold. The results might indicate when properties are more liquid and which assets are more liquid than others, but it is possible that some buildings with desirable characteristics are held for longer by owners and would trade rapidly if offered for sale. Fisher and Young (2000) study holding periods using the NCREIF database and Collett, Lizieri, and Ward (2003) examine these for institutional grade U.K. real estate. The latter find that holding periods have reduced over time, and vary with market state and by type of property.

In contrast to volumes, tightness, as captured by bid-ask spreads, is much more difficult to measure for private real estate than for many financial assets as there is not an observable bid-ask spread for different assets in the real estate investment market. However, there is a distinction between the reservation price of a seller (at which they are prepared to sell) and that of a buyer. The distance between these determines the likelihood of a sale taking place: where reservation prices meet or overlap, a buyer and seller can conclude a trade, but, where they do not, the asset concerned will remain unsold.

More generally, a distribution of reservation prices that reflects the views of potential buyers of real estate assets can be inferred as can a similar distribution of reservation prices that reflects views of potential sellers. Such distributions are proposed by Fisher, Gatzlaff, Geltner, and Haurin (2003). They describe how the shape and extent of overlap between these distributions influences the number of assets likely to trade [see also Clayton, MacKinnon, and Peng (2008)]. They argue that variations in liquidity in the real estate market over time make the interpretation of real estate price series more difficult. This is because prices tend to adjust slowly to changes in real estate market conditions. In fact, the nature of real estate markets causes adjustments to occur in prices, volumes, and time to transact when market conditions change, as well as in the mix of assets being traded. As such, Fisher, Gatzlaff, Geltner, and Haurin (2003) argue that real estate indices need to be adjusted to reflect the differential ability to enter and exit the market at different points of the real estate cycle.

Adjustments to create constant liquidity real estate price series for the U.S. are tested by Fisher, Gatzlaff, Geltner, and Haurin (2003), Goetzmann and Peng (2006), and Fisher, Geltner, and Pollakowski (2007). Subsequently, the relation between constant liquidity and uncorrected price series has been used by Clayton, MacKinnon, and Peng (2008) to derive a measure of market-wide liquidity, while Buckles (2008) proposes a liquidity index based on a more complicated procedure. This strand of research resulted in the publication of a liquidity series by the MIT Center for Real Estate, alongside the U.S. transaction-based price series resulting from the work of Fisher, Geltner, and Pollakowski (2007). However, similar, constant-liquidity transaction price indices do not exist in other countries and are a prerequisite for creating a liquidity index of this nature.

The other major area of examination has been in regard to the time it takes to transact assets in the private real estate investment market. As noted earlier, a substantial body of research has explored time-on-the-market for residential property, but there are far fewer studies for commercial real estate. McNamara (1998) conducted survey work to estimate average transaction times for U.K. real estate investments. For sales, he reported a marketing period of four to eight weeks and a due diligence period of four to twelve weeks depending on property type. However, IPF (2004) found actual times to be longer, with a median sale time of 190 days and considerable dispersion in transaction times as well. Scofield (2013), who considers the transaction process from the buy side, finds that time to transact is time varying and that transactions were conducted more rapidly during the boom phase of the U.K. real estate cycle. This is reinforced by Devaney and Scofield (2015), who also suggest that features of the asset and counterparties involved are influential in explaining why some transactions take longer than others.

The nature of real estate markets (heterogeneous assets with limited numbers of buyers and sellers operating under various economic constraints) means that the length of the time-on-the-market is likely to be affected by many factors. Thus, when real estate investors come to sell a property, they face uncertainty not only in regard to transaction price (price risk), but also around the time it will take to sell (marketing period risk). In contrast, many financial assets can be sold instantaneously through public exchanges and so investors do not bear marketing period risk.

The nature and behavior of marketing period risk is investigated by Lin and Vandell (2007), who highlight the importance to investors of the hidden risk exposure that occurs during the extended marketing period of a commercial real estate asset. They estimate the extent to which ex post data on real estate performance understates the ex ante risk exposure taken by real estate investors, because it does not take into account the asset risk exposure during the marketing period or the uncertainty of the marketing period itself. This work is extended by Bond, Hwang, Lin, and Vandell

(2007), who calibrate such models using the transaction times reported in IPF (2004). They suggest that the ex ante level of risk exposure for a commercial real estate investor is around one and a half times that obtained from historical statistics. Meanwhile, Lin and Liu (2008) consider how the level of risk might vary with the financial circumstances and investment horizons of different types of sellers, while the analysis has been extended still further in more recent work by Cheng, Lin, and Liu (2010, 2013a, 2013b).

This work provides evidence of the importance of liquidity in private real estate markets and, to some extent, the degree of liquidity for different types of property or in different periods. However, the range of measures produced and tested in a private real estate context is much narrower than for either REITs or financial assets and is less developed for commercial real estate than for residential property, where data have traditionally been much richer.

EMPIRICAL EVIDENCE FOR OTHER REAL ESTATE VEHICLES

A descriptive overview of the public non-listed REIT sector is provided by Corgel and Gibson (2008) for U.S. funds and by Brounen, Eichholtz, and Ling (2009) for European funds. New empirical work on the estimation of liquidity premiums for investment vehicles different from REITs has started to be developed in recent times and this area is likely to be further analyzed in the future. So far, however, only a few articles have focused on European unlisted funds, debt products, and U.S. real estate mutual funds.

Schweizer, Haß, Johanning, and Rudolph (2013) discuss open-ended property funds, which offer apparently perfect daily liquidity, but failed to do in market conditions when liquidity was most required (redemptions are suspended if a threshold of requests is passed). They found that these vehicles offer a liquidity premium (measured as discount to NAV) of about 6% in the short run, but are not affected by liquidity risk in the long run and represent an attractive investment tool for long-term investors such as pension funds and other institutional players.

Marcato and Tira (2015) build upon the issue of suspended redemptions and estimate the impact of traded volumes on the price of such vehicles. Interestingly, if no effect is seen for aggregate transaction volumes, in line with previous findings in the finance literature, an opposite effect is found for money flows entering and exiting such funds. In fact, a smart money effect is estimated for outflows (i.e., capability of disinvesting timely), suggesting that current investors have access to better information. In contrast, a return-chasing behavior seems to drive inflows (i.e., investors enter funds that performed well in the past),[2] also thanks to the persistence of fund returns over time.

As a further step in the analysis of indirect causes of liquidity for unlisted funds, Wiley (2014) links the problem of suspended redemptions to managerial incentives and finds that an increase in compensation increases illiquidity risk indirectly because it reduces the ability to generate revenues and to raise equity capital to be used to fulfil redemption requests.

Finally, as far as debt products are concerned, we clearly see a shift in the pricing of liquidity risk for such products. If, before the last economic crisis, Nothaft, Pearce, and Stevanovic (2002) estimated a very small liquidity premium for agency (e.g., Freddie Mac, Fannie Mae) products, Kim (2009) later found that a liquidity shock is more likely for mortgage-backed securities (MBSs) than for government bonds if there is a sudden and significant drop of trading activities (as observed in 2008). Work from the Federal Reserve Bank of New York and Atlanta reinforces these results, linking the premium to vintage and a common factor (along with credit rating and an idiosyncratic factor) (Dungey, Dwyer, and Flavin, 2013). It shows the positive effect (around 10 to 25 bps) of the trading method on a ''to-be-announced'' (TBA) basis and no effect of the presence of a government credit guarantee.

Conclusion

In this review, we examine the literature on liquidity over recent decades and highlight the multi-faceted dimension of this phenomenon, the market imperfections causing it, the different measures used to estimate its significance empirically, and the main results obtained for real estate investment markets and products. We distinguish two types of liquidity. Trading (or market) liquidity refers to the nature of different assets and the markets in which they are traded. Funding liquidity is related to investors and their ability to gain funding to execute trades of those assets. The focus of this review is trading liquidity, several dimensions of which are presented and related to the time and costs of trading and its potential impact on prices: (1) tightness, (2) depth, (3) resilience, (4) breadth, and (5) immediacy. Different liquidity measures spring from the presence of six main market imperfections and we attempt to map these measures against the identified dimensions. This helps investors to understand market activity and their behavior in response to liquidity shocks. For each individual measure considered, both the formula for calculation and notes on its use in financial markets are set out.

The applicability of different measures to real estate markets and their occurrence in the real estate literature are examined. While this exercise shows that some measures may be impractical for private real estate markets, it also reveals their suitability and relevance for alternative investment vehicles in real estate, such as REIT shares, private equity funds or real estate debt. Aside from REITs, we find that the liquidity of alternative forms of real estate investment has received surprisingly little attention. We also identify other measures that are yet to be used with private real estate data, but which have potential and should be explored. A clear example is represented by Marcato (2015), who estimates liquidity premia using volume-based, time-based, and price-impact measures to improve confidence in final outcomes and the estimation process.

The estimation of liquidity premia for private real estate assets or funds is an area that requires more investigation. Liquidity is often suggested as a factor that can explain the risk premium puzzle for private real estate alongside issues concerning measurement of real estate returns. However, the extent of any liquidity premium is rarely quantified. Furthermore, there is a long history of trying to reconcile theoretical allocations to real estate from portfolio modelling with actual allocations by institutional investors. If liquidity could be incorporated formally into such models, more realistic solutions for portfolio weights to different assets, including private real estate, might be forthcoming. The time it takes to transact commercial real estate is also rarely researched, in contrast to the large amount of literature on this issue for residential real estate assets.

This work represents a comprehensive review of studies on liquidity and its impact on pricing. We hope that empirical work might spark from this review, improving the debate on such an important issue for markets with real as opposed to financial assets.

ENDNOTES

1. Throughout, we mean economic agents rather than estate agents/brokers when we use the word "agents."
2. See also Chou and Hardin III (2014) for U.S. real estate mutual funds.

REFERENCES

Acharya, V.V. and L.H. Pedersen. Asset Pricing with Liquidity Risk. *Journal of Financial Economics*, 2005, 77:2, 375–410.

Acharya, V.V. and S. Viswanathan. Leverage, Moral Hazard, and Liquidity. *Journal of Finance*, 2011, 66:1, 99–138.

Acker, D., M. Stalker, and I. Tonks. Daily Closing Inside Spreads and Trading Volumes around Earnings Announcements. *Journal of Business Finance & Accounting*, 2002, 29 (9–10), 1149–79.

Albagli, E. Amplification of Uncertainty in Illiquid Markets. University of Southern California Working Paper, 2011.

Amihud, Y. Illiquidity and Stock Returns: Cross-section and Time Series Effects. *Journal of Financial Markets*, 2002, 5:1, 31–56.

Amihud, Y. and H. Mendelson. Dealership Market: Market-making with Inventory. *Journal of Financial Economics*, 1980, 8:1, 31–53.

——. Asset Pricing and the Bid-Ask Spread. *Journal of Financial Economics*, 1986, 17:2, 223–49.

Amihud, Y., H. Mendelson, and L.H. Pedersen. Liquidity and Asset Prices. *Foundations and Trends in Finance*, 2005, 1:4, 269–364.

Avramov, D., T. Chordia, and A. Goyal. Liquidity and Autocorrelations in Individual Stock Returns. *Journal of Finance*, 2006, 61:5, 2365–94.

Bacidore, J.M. The Impact of Decimalization on Market Quality: An Empirical Investigation of the Toronto Stock Exchange. *Journal of Financial Intermediation*, 1997, 6:2, 92–120.

Bacidore, J.M., R.H. Battalio, and R.H. Jennings. Depth Improvement and Adjusted Price Improvement on the New York Stock Exchange. *Journal of Financial Markets*, 2002, 5:2, 169–95.

Baker, H.K. Trading Location and Liquidity: An Analysis of U.S. Dealer and Agency Markets for Common Stocks. *Financial Markets Institutions and Instruments*, 1996, 5:4, 1–51.

Bao, J., J. Pan, and J. Wang. The Illiquidity of Corporate Bonds. *Journal of Finance*, 2011, 66:3, 911–46.

Barclay, M.J., W.G. Christie, J.H. Harris, E. Kandel, and P.H. Schultz. Effects of Market Reform on the Trading Costs and Depths of NASDAQ Stocks. *Journal of Finance*, 1999, 54:1, 1–34.

Baruch, S. Insider Trading and Risk Aversion. *Journal of Financial Markets*, 2002, 5:4, 451–64.

Battalio, R., J. Greene, and R. Jennings. Order Flow Distribution, Bid-Ask Spreads, and Liquidity Costs: Merrill Lynch's Decision to Cease Routinely Routing Orders to Regional Stock Exchanges. *Journal of Financial Intermediation*, 1998, 7:4, 338–58.

Beber, A., J. Driessen, and P. Tuijp. Pricing Liquidity Risk with Heterogeneous Investment Horizons. Cass Business School Working Paper, 2012.

Bekaert, G., C.R. Harvey, and C. Lundblad. Liquidity and Expected Returns: Lessons from Emerging Markets. *Review of Financial Studies*, 2007, 20:6, 1783–1831.

Below, S.D., J.K. Kiely, and W. McIntosh. An Examination of Informed Traders and the Market Microstructure of Real Estate Investment Trusts. *Journal of Real Estate Research*, 1995, 10:3, 335–61.

Benefield, J.D., C.L. Cain, and K.H. Johnson. A Review of Literature Utilizing Simultaneous Modeling Techniques for Property Price and Time-On-Market. *Journal of Real Estate Literature*, 2014, 22:2, 149–75.

Benefield, J.D. and W.G. Hardin III. Does Time-on-Market Measurement Matter? *Journal of Real Estate Finance & Economics*, 2015, 50:1, 52–73.

Benveniste, L., D.R. Capozza, and P. Seguin. The Value of Liquidity. *Real Estate Economics*, 2001, 29:4, 633–60.

Bernstein, P.L. Liquidity, Stock Markets, and Market Makers. *Financial Management*, 1987, Summer, 54–62.

Bertin, W., D. Michayluk, L. Prather, and P. Kofman. Intraday REIT Liquidity. *Journal of Real Estate Research*, 2005, 27:2, 155–76.

Bhasin, V., R.A. Cole, and J.K. Kiely. Changes in REIT Liquidity 1990–1994: Evidence from Intra-day Transactions. *Real Estate Economics*, 1997, 25:4, 615–30.

Bond, S.A. and Q. Chang. Liquidity Dynamics across Public and Private Markets. *Journal of International Money and Finance*, 2012, 31:7, 1890–1910.

Bond, S.A., S. Hwang, Z. Lin, and K.D. Vandell. Marketing Period Risk in a Portfolio Context: Theory and Empirical Estimates from the U.K. Commercial Real Estate Market. *Journal of Real Estate Finance and Economics*, 2007, 34:4, 447–61.

Brockman, P. and D.Y. Chung. Commonality in Liquidity: Evidence from an Order-driven Market Structure. *Journal of Financial Research*, 2002, 25:4, 521–39.

Brounen, D., P. Eichholtz, and D. Ling. The Liquidity of Property Shares: An International Comparison. *Real Estate Economics*, 2009, 37:3, 413–45.

Brunnermeier, M.K. and L.H. Pedersen. Predatory Trading. *Journal of Finance*, 2005, 60:4, 1825–63.

——. Market Liquidity and Funding Liquidity. *Review of Financial Studies*, 2009, 22, 2201–38.

Buckles, B.W. Liquidity Dynamics in Commercial Real Estate. *Journal of Real Estate Portfolio Management*, 2008, 14:4, 307–24.

Butler, A.W., G. Grullon, and J.P. Weston. Can Managers Forecast Aggregate Market Returns? *Journal of Finance*, 2005, 60:2, 963–86.

Cannon, S.E. and R.A. Cole. Changes in REIT Liquidity 1988–2007: Evidence from Daily Data. *Journal of Real Estate Finance and Economics*, 2011, 43:1–2, 258–80.

Cespa, G. and T. Foucault. Illiquidity Contagion and Liquidity Crashes. *Review of Financial Studies*, 2014, 27:6, 1615–60.

Chau, M. and D. Vayanos. Strong Form Efficiency with Monopolistic Insiders. *Review of Financial Studies*, 2008, 21:5, 2275–2306.

Chen, L., D. Lesmond, and J. Wei. Corporate Yield Spreads and Bond Liquidity. *Journal of Finance*, 2007, 62:1, 119–49.

Cheng, P., Z. Lin, and Y. Liu. Illiquidity, Transaction Cost, and Optimal Holding Period for Real Estate: Theory and Application. *Journal of Housing Economics*, 2010, 19:2, 109–18.

——. Performance of Thinly Traded Assets: A Case in Real Estate. *The Financial Review*, 2013a, 48:3, 511–36.

——. Liquidity Risk of Private Assets: Evidence from Real Estate Markets. *The Financial Review*, 2013b, 48:4, 671–96.

Chordia, T., R. Roll, and A. Subrahmanyam. Market Liquidity and Trading Activity. *Journal of Finance*, 2001, 56:2, 501–30.

Chordia, T. and B. Swaminathan. Trading Volume and Cross-Autocorrelations in Stock Returns. *Journal of Finance*, 2000, 55:2, 913–35.

Chou, W.H. and W.G. Hardin III. Performance Chasing, Fund Flows and Fund Size in Real Estate Mutual Funds. *Journal of Real Estate Finance and Economics*, 2014, 49:3, 379–412.

Christie, W.G. and P.H. Schultz. Why do NASDAQ Market Makers Avoid Odd-Eighth Quotes? *Journal of Finance*, 1994, 49:5, 1813–40.

Clayton, J. and G. MacKinnon. Measuring and Explaining Changes in REIT Liquidity: Moving Beyond the Bid-Ask Spread. *Real Estate Economics*, 2000, 28:1, 89–115.

Clayton, J., G. MacKinnon, and L. Peng. Time Variation of Liquidity in the Private Real Estate Market: An Empirical Investigation. *Journal of Real Estate Research*, 2008, 30:2, 125–60.

Cole, R. Changes in REIT Liquidity 1990–94: The Role of New REITs. Paper presented at the 1998 AREUEA meeting, Chicago, IL.

Collett, D., C. Lizieri, and C. Ward. Timing and the Holding Periods of Institutional Real Estate. *Real Estate Economics*, 2003, 31:2, 205–22.

Constantinides, G.M. Capital Market Equilibrium with Transaction Costs. *The Journal of Political Economy*, 1986, 94:4, 842–62.

Corgel, J. and S. Gibson. Real Estate Private Equity: The Case of U.S. Unlisted REITs. *Journal of Property Investment & Finance*, 2008, 26:2, 132–50.

Corgel, J., W. McIntosh, and S. Ott. Real Estate Investment Trusts: A Review of the Financial Economics Literature. *Journal of Real Estate Literature*, 1995, 3:1, 13–43.

Corwin, S.A. Differences in Trading Behavior across NYSE Specialist Firms. *Journal of Finance*, 1999, 54:2, 721–45.

Corwin, S.A. and M.L. Lipson. Order Flow and Liquidity around NYSE Trading Halts. *Journal of Finance*, 2000, 55:4, 1771–1801.

Danielsen, B.R. and D.M. Harrison. The Impact of Potential Private Information on REIT Liquidity. *Journal of Real Estate Research*, 2000, 19:1, 49–71.

Das, S. and P. Hanouna. Run Lengths and Liquidity. *Annals of Operations Research*, 2010, 176: 1, 127–52.

DeMarzo, P. and B. Urosevic. Ownership Dynamics and Asset Pricing with a Large Shareholder. *Journal of Political Economy*, 2006, 114:4, 774–815.

Demsetz, H. The Cost of Transacting. *Quarterly Journal of Economics*, 1968, 82:1, 33–53.

Dennis, P. and D. Strickland. The Effect of Stock Splits on Liquidity and Excess Returns: Evidence from Shareholder Ownership Composition. *Journal of Financial Research*, 2003, 26:3, 355–70.

Devaney, S. and D. Scofield. Liquidity and the Drivers of Search, Due Diligence and Transaction Times for U.K. Commercial Real Estate Investments. *Journal of Property Research*, 2015, 32: 4, 362–83.

Duffie, D., N. Garleanu, and L.H. Pedersen. Securities Lending, Shorting and Pricing. *Journal of Financial Economics*, 2002, 66:2–3, 307–39.

——. Over-the-Counter Markets. *Econometrica*, 2005, 73:6, 1815–47.

——. Valuation in Over-the-Counter Markets. *Review of Financial Studies*, 2007, 20:6, 1865–1900.

Dungey, M., G. Dwyer, and T. Flavin. Systematic and Liquidity Risk in Subprime Mortgage-backed Securities. *Open Economies Review*, 2013, 24:1, 5–32.

Easley, D. and M. O'Hara. Information and the Cost of Capital. *Journal of Finance*, 2004, 59:4, 1553–83.

Feng, Z., S. Price, and C.F. Sirmans. An Overview of Equity REITs: 1993–2009. *Journal of Real Estate Literature*, 2011, 19:2, 307–44.

Fisher, J., D. Gatzlaff, D. Geltner, and D. Haurin. Controlling for the Impact of Variable Liquidity in Commercial Real Estate Price Indices. *Real Estate Economics*, 2003, 31:2, 269–303.

——. An Analysis of the Determinants of Transaction Frequency of Institutional Commercial Real Estate Investment Property. *Real Estate Economics*, 2004, 32:2, 239–64.

Fisher, J., D. Geltner, and H. Pollakowski. A Quarterly Transactions-based Index of Institutional Real Estate Investment Performance and Movements in Supply and Demand. *Journal of Real Estate Finance and Economics*, 2007, 34:1, 5–33.

Fisher, J., D.C. Ling, and A. Naranjo. Institutional Capital Flows and Return Dynamics in Private Commercial Real Estate Markets. *Real Estate Economics*, 2009, 37:1, 85–116.

Fisher, J.D. and M.S. Young. Institutional Property Tenure: Evidence from the NCREIF Database. *Journal of Real Estate Portfolio Management*, 2000, 6:4, 327–38.

Franzoni, F., E. Nowak, and L. Phalipppou. Private Equity Performance and Liquidity Risk. *Journal of Finance*, 2012, 67:6, 2341–73.

Fuerst, F. and G. Marcato. Style Analysis in Real Estate Market: Beyond the Sector and Region Dichotomy. *Journal of Portfolio Management*, 2009, 35:5, 104–17.

Glascock, J. and R. Lu-Andrews. An Examination of Macroeconomic Effects on the Liquidity of REITs. *Journal of Real Estate Finance and Economics*, 2014, 49:1, 23–46.

Glosten, L. Insider Trading, Liquidity and the Role of the Monopolist Specialist. *Journal of Business*, 1989, 62:2, 211–35.

Glosten, L.R. and P.R. Milgrom. Bid, Ask and Transaction Prices in a Specialist Market with Heterogeneously Informed Traders. *Journal of Financial Economics*, 1985, 14:1, 71–100.

Goetzmann, W. and L. Peng. Estimating House Price Indexes in the Presence of Seller Reservation Prices. *Review of Economics and Statistics*, 2006, 88:1, 100–12.

Goldstein, M.A. and K. Kavajecz. Eighths, Sixteenths, and Market Depth: Changes in Tick Size and Liquidity Provision on the NYSE. *Journal of Financial Economics*, 2000, 56:1, 125–49.

Goodhart, C. Liquidity Risk Management. *Financial Stability Review*, February 11, 2008, Banque de France.

Goyenko, R., C.W. Holden, C. Lundblad, and C. Trzcinka. Horseraces of Monthly and Annual Liquidity Measures. Indiana University working paper, 2005.

——. Do Liquidity Measures Measure Liquidity? *Journal of Financial Economics*, 2009, 92:2, 153–81.

Grammig, J., D. Schiereck, and E. Theissen. Knowing Me, Knowing You: Trader Anonymity and Informed Trading in Parallel Markets. *Journal of Financial Markets*, 2001, 4:4, 385–412.

Greene, J. and S. Smart. Liquidity Provision and Noise Trading: Evidence from the "Investment Dartboard" Column. *Journal of Finance*, 1999, 54:5, 1885–99.

Gromb, D. and D. Vayanos. Equilibrium and Welfare in Markets with Financially Constrained Arbitrageurs. *Journal of Financial Economics*, 2002, 66:2–3, 361–407.

Grossman, S.J. and M.H. Miller. Liquidity and Market Structure. *Journal of Finance*, 1988, 43: 3, 617–33.

Hamao, Y. and J. Hasbrouck. Securities Trading in the Absence of Dealers: Trades and Quotes on the Tokyo Stock Exchange. *Review of Financial Studies*, 1995, 8:3, 849–78.

Harris, F.H. deB., T.H. McInish, and R.A. Wood. Security Price Adjustment across Exchanges: An Investigation of Common Factor Components for Dow Stocks. *Journal of Financial Markets*, 2002, 5:3, 277–308.

Hart, O. and J. Moore. A Theory of Debt Based on the Inalienability of Human Capital. *Quarterly Journal of Economics*, 1994, 109:4, 841–79.

——. An Analysis of the Role of Hard Claims in Constraining Management. *American Economic Review*, 1995, 85:3, 567–85.

Hasbrouck, J. *Empirical Market Microstructure*. Oxford University Press, 2007.

Hasbrouck, J. and R.A. Schwartz. Liquidity and Execution Costs in Equity Markets. *Journal of Portfolio Management*, 1988, 14:3, 10–16.

Haurin, D., S. McGreal, A. Adair, L. Brown, and J.R. Webb. List Price and Sales Prices of Residential Properties during Booms and Busts. *Journal of Housing Economics*, 2013, 22:1, 1–10.

Hibbert, J., A. Kirchner, G. Kretzschmar, R. Li, and A. McNeil. Liquidity Premium: Literature Review of Theoretical and Empirical Evidence. Barrie+Hibbert research report, 2009.

Houweling, P., A. Mentink, and T. Vorst. Comparing Possible Proxies of Corporate Bond Liquidity. *Journal of Banking & Finance*, 2005, 29:6, 1331–58.

Huang, J. and J. Wang. Liquidity and Market Crashes. *Review of Financial Studies*, 2009, 22: 7, 2607–643.

Huberman, G. and D. Halka. Systematic Liquidity. *Journal of Financial Research*, 2001, 24:2, 161–78.

Huddart, S., J. Hughes, and C. Levine. Public Disclosure and Dissimulation of Insider Trades. *Econometrica*, 2001, 69:3, 665–81.

IPF. *Liquidity in Commercial Property Markets*. London: Investment Property Forum, 2004.

Jankowitsch, R., H. Mösenbacher, and S. Pichler. Measuring the Liquidity Impact on EMU Government Bond Prices. *The European Journal of Finance*, 2006, 12:2, 153–69.

Jones, C.M. and M.I. Lipson. Price Impacts and Quote Adjustment on the NASDAQ and NYSE/ AMEX. Paine Webber working paper no. 99-08, 1999.

Jones, C.M., G. Kaul, and M.L. Lipson. Transactions, Volume, and Volatility. *Review of Financial Studies*, 1994, 7:4, 631–51.

Jud, G.D., D.T. Winkler, and G.E. Kissling. Price Spreads and Residential Housing Market Liquidity. *Journal of Real Estate Finance and Economics*, 1995, 11:3, 251–60.

Kang, W. and H. Zhang. Measuring Liquidity in Emerging Markets. *Pacific-Basin Finance Journal*, 2014, 27, 49–71.

Karolyi, G.A., K.H. Lee, and M.A. Van Dijk. Understanding Commonality In Liquidity Around the World. *Journal of Financial Economics*, 2012, 105 (1), 82–112.

Karpoff, J.M. The Relation between Price Changes and Trading Volume: A Survey. *Journal of Financial and Quantitative Analysis*, 1987, 22:1, 109–26.

Kavajecz, K.A. A Specialist's Quoted Depth and the Limit Order Book. *Journal of Finance*, 1999, 54:2, 747–71.

Kavajecz, K.A. and E.R. Odders-White. An Examination of Changes in Specialists' Posted Price Schedules. *Review of Financial Studies*, 2001, 14:3, 681–704.

Kerry, W. Measuring Financial Market Liquidity. *Journal of Risk Management in Financial Institutions*, 2008, 1:2, 181–90.

Kim, J. An Empirical Investigation of MBS Liquidity Risk. *Journal of Fixed Income*, 2009, 18: 4, 39–46.

Kleymenova, A., E. Talmor, and F. Vasvari. Liquidity in the Secondaries Private Equity Market. London Business School working paper, March 2012.

Korajczyk, R.A. and R. Sadka. Pricing the Commonality across Alternative Measures of Liquidity. *Journal of Financial Economics*, 2008, 87:1, 45–72.

Krishnamurthy, A. Amplification Mechanisms in Liquidity Crises. *American Economic Journal: Macroeconomics*, 2010, 2:3, 1–30.

Kyle, A. Continuous Auctions and Insider Trading. *Econometrica*, 1985, 53:6, 1315–35.

——. Informed Speculation with Imperfect Competition. *Review of Economic Studies*, 1989, 56:3, 317–56.

Lee, C.M.C., B. Mucklow, and M.J. Ready. Spreads, Depths and the Impact of Earnings Information: An Intraday Analysis. *Review of Financial Studies*, 1993, 6:2, 345–74.

Lesmond, D.A. Liquidity of Emerging Markets. *Journal of Financial Economics*, 2005, 77:2, 411–52.

Lesmond, D.A., J.P. Ogden, and C.A. Trzcinka. A New Estimate of Transaction Costs. *Review of Financial Studies*, 1999, 12:5, 1113–41.

Lin, J.C., G.C. Sanger, and G.G. Booth. Trade Size and Components of the Bid-Ask Spread. *Review of Financial Studies*, 1995, 8:4, 1153–83.

Lin, Z. and Y. Liu. Real Estate Returns and Risk with Heterogeneous Investors. *Real Estate Economics*, 2008, 36:4, 753–76.

Lin, Z. and K.D. Vandell. Illiquidity and Pricing Biases in the Real Estate Market. *Real Estate Economics*, 2007, 35:3, 291–330.

Ling, D., G. Marcato, and P. McAllister. The Dynamics of Asset Prices, Capital Flows, and Transaction Activity in Illiquid, Informational Inefficient, Commercial Real Estate Markets. *Journal of Real Estate Finance and Economics*, 2009, 39:3, 359–83.

Liu, J. and F. Longstaff. Losing Money on Arbitrage: Optimal Dynamic Portfolio Choice in Markets with Arbitrage Opportunities. *Review of Financial Studies*, 2004, 17:3, 611–41.

Longstaff, F.A., S. Mithal, and E. Neis. Corporate Yield Spreads: Default Risk or Liquidity? New Evidence from the Credit Default Swap Market. *Journal of Finance*, 2005, 60:5, 2213–53.

Mann, S.V. and P. Ramanlal. The Dealers' Price/Size Quote and Market Liquidity. *Journal of Financial Research*, 1996, 19:2, 243–71.

Marcato, G. Liquidity Pricing of Non-liquid Assets. Henley Business School REP working paper, 2015

Marcato, G. and G.A. Tira. Smart-money Effect and Return Chasing Behaviour: Lessons from Real Estate Fund Flows During the Economic Crisis. Henley Business School REP working paper, 2015.

Marcato, G. and C. Ward. Back from Beyond the Bid-Ask Spread: Estimating Liquidity in International Markets. *Real Estate Economics*, 2007, 35:4, 599–622.

McNamara, P. Exploring Liquidity: Recent Survey Findings. Paper presented at the 7th Investment Property Databank Conference, Brighton, November 1998.

Nelling, E., J. Mahoney, T. Hildebrand, and M. Goldstein. Real Estate Investment Trusts, Small Stocks and Bid-Ask Spreads. *Real Estate Economics*, 1995, 23:1, 45–63.

Nothaft, F., J.E. Pearce, and S. Stevanovic. Debt Spreads between GSEs and Other Corporations. *Journal of Real Estate Finance and Economics*, 2002, 25:2, 151–72.

O'Hara, M. *Market Microstructure Theory*. Cambridge, MA: Blackwell, 1995.

——. Liquidity and Price Discovery. *Journal of Finance*, 2003, 58:4, 1335–54.

Pastor, L. and R.F. Stambaugh. Liquidity Risk and Expected Stock Returns. *Journal of Political Economy*, 2003, 111:3, 642–85.

Peng, L. Trading Takes Time. Yale School of Management working paper, 2001.

Roll, R. A Simple Implicit Measure of the Effective Bid-Ask Spread in an Efficient Market. *Journal of Finance*, 1984, 39:4, 1127–39.

Rouwenhorst, K.G. Local Return Factors and Turnover in Emerging Stock Markets. *Journal of Finance*, 1999, 54:4, 1439–64.

Sadka, R. Liquidity Risk and the Cross-section of Hedge-fund Returns. *Journal of Financial Economics*, 2010, 98:1, 54–71.

Sarr, A. and T. Lybek. Measuring Liquidity in Financial Markets. IMF working paper no. 02/232, 2002.

Schweizer, D., L.H. Haß, L. Johanning, and B. Rudolph. Do Alternative Real Estate Investment Vehicles Add Value to REITs? Evidence from German Open-ended Property Funds. *Journal of Real Estate Finance and Economics*, 2013, 47:1, 65–82.

Scofield, D. Time to Completion Liquidity in U.K. Commercial Real Estate Investment: 2000–2008. *Journal of European Real Estate Research*, 2013, 6:1, 34–47.

Shleifer, A. and R. Vishny. Liquidation Values and Debt Capacity: A Market Equilibrium Approach. *Journal of Finance*, 1992, 47:4, 1343–66.

——. The Limits of Arbitrage. *Journal of Finance*, 1997, 52:1, 35–55.

Sirmans, G.S., L. MacDonald, and D.A. Macpherson. A Meta-Analysis of Selling Price and Time-on-the-Market. *Journal of Housing Research*, 2010, 19:2: 139–52.

Stoll, H.R. The Supply of Dealer Services in Securities Markets. *Journal of Finance*, 1978, 33:4, 1133–51.

Subrahmanyam, A. Liquidity, Return and Order-Flow Linkages between REITs and the Stock Market. *Real Estate Economics*, 2007, 35:3, 383–408.

Vayanos, D. and J. Wang. Theories of Liquidity. *Foundations and Trends in Finance*, 2011, 6:4, 221–317.

Vayanos, D. and T. Wang. Search and Endogenous Concentration of Liquidity in Asset Markets. *Journal of Economic Theory*, 2007, 136:1, 66–104.

Watanabe, A. and M. Watanabe. Time-varying Liquidity Risk and the Cross-section of Stock Returns. *Review of Financial Studies*, 2008, 21:6, 2449–86.

Wiley, J.A. Illiquidity Risk in Non-listed Funds: Evidence from REIT Fund Exits and Redemption Suspensions. *Journal of Real Estate Finance and Economics*, 2014, 49:2, 205–36.

Zietz, E., G.S. Sirmans, and H.S. Friday. The Environment and Performance of Real Estate Investment Trusts. *Journal of Real Estate Portfolio Management*, 2003, 9:2, 127–65.

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