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The Expected Illiquidity Premium: Evidence from Equity Index-Linked Bonds ⋆

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Abstract. We examine a set of equity index-linked bonds that provide the same payoff as an investment in an equity index, but are relatively illiquid. We demonstrate that these securities sell at a discount relative to their underlying value and hence have higher expected returns. We show that this apparent mispricing can be attributed to the illiquidity of the bonds. Trading costs for equity-linked bonds, as measured by bid-ask spreads, are free of any asymmetric information or inventory holding cost component; hence the only illiquidity component left is clearing costs. This study shows that, even in the absence of asymmetric information and inventory holding costs, illiquidity depresses asset prices and therefore increases expected security returns. Using an ex ante measure of the expected return premium due to illiquidity, we link the time-series variation in the illiquidity premium to security-specific attributes related to their marketability. We show that liquidity risk has a systematic component, and relate this market-wide factor to a number of macroeconomic variables that have previously been shown to be related to illiquidity.

1. Introduction

There is a growing literature on the liquidity of financial assets and its impact on expected returns. Liquid, as opposed to illiquid, markets are generally viewed as those that accommodate trading with the least impact on price, as outlined by O'Hara (1995) and Stoll (2000). Many empirical and theoretical studies argue that in the presence of high trading costs, securities compensate investors with a higher expected return. Other studies find that when trading costs are high, investors change their behavior by lengthening holding horizons; and hence illiquid assets do not necessarily provide higher expected returns.

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However, there are several shortcomings in the empirical literature on liquidity effects among traded securities:

- Prior studies often use ex post returns as a proxy for expectations, and the estimated liquidity effect is therefore conditioned on the validity of the benchmark.[1]
- There have been attempts at estimating *ex ante* returns for illiquid traded securities but these studies have largely been limited to notes and bonds, and are not readily extrapolated to equities.[2]
- Several previous studies have examined *ex ante* return premia for non-traded securities.[3] A drawback of these studies is that, by definition, they do not have prices obtained in a competitive market but have to resort to prices that are exogenously determined.
- Earlier work was unable to isolate the impact of an individual source of stock market illiquidity, such as execution costs, inventory risk, or adverse-selection risk.
- Most importantly, previous studies have not had time series of a clean measure of expected return premia due to illiquidity. Therefore, time variations in ex ante liquidity premia could not be examined and linked to other market factors.

We overcome these drawbacks by examining the pricing of equity index-linked bonds (typically referred to as equity-linked bonds or ELBs). ELBs are exchange-traded corporate bonds whose payoff replicates a cost-free equity index fund, but whose trading volume and transaction frequency is low. This type of security has a principal that is linked to a broad equity market index and a coupon that equals the dividend yield of the underlying equity index. At maturity, investors receive a payment equal to the level of the index at that time.[4] The quantity of ELBs that is issued is small relative to the issuer's assets and the securities are immediately repayable if asset cover deteriorates below a pre-defined threshold. Hence, there is essentially no credit risk. Though issued at par, ELBs tend to trade at a discount from shortly after issue, and this discount can at times be sizable.

These securities provide a unique opportunity for isolating the impact of liquidity on expected returns because of three characteristics: First, due to the absence

[1] These studies include Amihud and Mendelson (1986), Eleswarapu and Reinganum (1993), Brennan and Subrahmanyam (1996), Barclay et al. (1997), Eleswarapu (1997), Chordia et al. (2001, 2002), and Pastor and Stambaugh (2003). Examples of benchmark choice are Amihud and Mendelson's (1986) use of the CAPM, and Brennan and Subrahmanyam's (1996) use of the Fama-French three-factor model.

[2] See, for example, Amihud and Mendelson (1991), Warga (1992), Daves and Ehrhardt (1993), Boudoukh and Whitelaw (1994), Kamara (1994), Krishnamurthy (2002), and Strebulaev (2001). Also see Cooper and Davydenko (2002) on corporate debt.

[3] Studies of this type include Silber (1991) who examines restricted equities, as well as Brenner et al. (2001) who analyze non-traded currency options.

[4] In contrast to issues of corporate bonds with attached options, ELBs provide index exposure with no cap or floor on income or redemption value; see Roberts et al. (2002).

of a specific risk component in ELBs, market maker inventory costs are negligible.[5] Second, since ELBs track the underlying index there is no opportunity to acquire superior information concerning the security's fundamental value, so these securities cannot experience adverse selection costs. Third, ELBs are illiquid: their aggregate value is under \$0.5 billion and ELBs average only a couple of transactions per week. We are therefore able to investigate the impact of clearing costs, isolated from inventory and informational costs.

Glosten and Harris (1988) highlight the important role of information-based trades. Easley et al. (1996) point out that there is a higher propensity for information-based trading in low-volume stocks, which suggests that their large spreads are not merely the result of fixed clearing costs. For most securities, illiquidity arising from fixed clearing costs is contaminated by other sources of illiquidity and cannot be isolated (see Easley et al., 2002, and Van Ness et al., 2001). This problem does not arise with ELBs. We demonstrate that the price discounts for ELBs cannot be attributed solely to noise but are caused by the asset's illiquidity. Furthermore, the discounts are highly correlated, and their liquidity has a systematic component.

The ELBs examined in this study comprise the universe of this security type. They are issued by actively-managed, closed-end mutual funds whose objective is to obtain low-risk leverage by matching liabilities to assets. The issuers seek to maximize the overall expected performance of their active strategy by investing over 100 percent of their net worth in stocks that are expected to outperform. This is accomplished by shorting some of the fund's exposure to its benchmark. A short position is achieved by issuing corporate debt with ELB characteristics. For fund managers who are confident of their stock-selection ability, ELBs potentially dominate other forms of leverage.[6]

All existing ELBs were issued in the late 1980s or 1990s and are listed on the London Stock Exchange (LSE). The LSE is a dealership market. About 85-90 percent of customer transactions placed with a broker-dealer are executed against a market maker. The broker-dealer may choose to act as a principal and buy or sell from his own account, or he may act solely as an agent and cross the order with

[5] There is a negligible inventory cost because a position in ELBs is equivalent to a position in the underlying index. Any required hedging transaction would therefore be small and inexpensive. Its cost would be positive about half the time, and – when ELB exposure is in the opposite direction to trading exposure – negative about half the time.

[6] The closed-end funds that issued ELBs wanted to commit to a long-term leveraged position in order to signal their own confidence in their ability to outperform their benchmark. In this way they were trying to reduce the closed-end fund discount relative to its net asset value. The ELB issuers are able to obtain low-risk financing by linking the value of their debt to the level of their benchmark index, thereby ensuring that the value of their liability is likely to be reduced when their assets are likely to decrease. For the issuer, ELBs dominate gaining leverage through short positions in futures because they are a long-term commitment, are designed to track their underlying equity index perfectly, and have neither basis risk nor a need to be "rolled over" into new contracts. Flotation costs only have to be paid once for a security life of about ten to fifteen years.

another client. Market makers typically do not attempt to find counterparties for their trades but take customer orders into their inventories. All ELBs have either one or two market makers who post firm bid and ask quotes which, however, are improved quite frequently upon negotiation with the client. Hansch et al. (1999) report that it is quite common for market makers at the LSE to set wide quoted spreads in order to reduce the frequency of quote revision. Hence, effective spreads are usually considerably tighter than quoted spreads. Client orders can only be market orders; limit orders do not exist.

ELBs are typically issued with a 10–15 year maturity and most are linked to the FTSE All-Share Index. Their market capitalizations vary considerably, but in some cases they are rather small ranging between $15 million and $235 million at issuance.[7] As we explain later, they are essentially non-callable instruments. However, in some cases relatively large amounts have been repurchased and subsequently redeemed, as can be inferred from the last two columns of Table I, Panel A. In parentheses we show the ELBs' market capitalization as a proportion of the total assets of the issuer, which averaged between 3 and 32 percent.[8] Panel B of Table I shows a number of liquidity measures, namely the average quoted bid-ask spread, the average effective bid-ask spread, the average number of trades per annum, and the mean and median trade sizes. As can be seen in the table, most ELBs are very illiquid as far as spread size, and number of transactions are concerned; but both the mean and median trade sizes are relatively large. The mean trade size ranges between $19,000 and $126,000, though the median trade size is between $8,000 and $25,000, indicating that there is a number of very large transactions and many medium and smaller transactions.

The paper is organized as follows: Section 2 describes the data. Section 3 describes the price discounts of the securities studied. Section 4 examines possible explanations for the price discounts. Section 5 relates ELB pricing to their bid-ask spreads. Section 6 presents the time series analysis of the discounts and presents evidence that fluctuations in ELB liquidity influence ELB discounts. Section 7 examines whether the expected return on ELBs is influenced by the same factors as illiquidity premia for other assets. Section 8 concludes.

2. Data

We use transaction data for the complete population of ELBs for their entire history from April 1989 to the end of 2001. Transaction prices are primarily from the LSE, with the remainder hand-collected from the Stock Exchange Daily Official List. Trading volumes are partly from the Naik et al. (2001) database, while the remainder is transcribed from the LSE's electronic data service. We have price and

[7] We use a $/£ exchange rate of 1.62.

[8] In addition to the ELB, only British Assets, Scottish American, and British Empire Securities had other debt outstanding averaging 3 percent, 1 percent and 9 percent respectively of the issuers' total assets.

Table I. Overview of equity-linked bonds

Panel A: Characteristics

Issuer	Underlying index	Maturity date	Issue date	Market Cap. ($ m) At issue	Market Cap. ($ m) Average
British Assets	All-Share	31 Dec 05	24 Apr 89	235 (27%)	204 (21%)
Scottish American	All-Share	30 Sep 04	08 Sep 89	94 (16%)	123 (14%)
Fidelity Special Values	All-Share	31 Dec 04	16 Nov 94	15 (20%)	20 (19%)
British Empire Securities	All-Share	31 Mar 13	13 Oct 95	55 (13%)	21 (3%)
Fidelity European Values	Europe ex-UK	31 Dec 01	06 Nov 91	16 (21%)	40 (15%)
Smaller Companies	SmallCap ex-IT	31 Oct 03	16 Oct 98	44 (38%)	53 (32%)

Panel B: Liquidity overview

Issuer	Quoted spread (%)	Effective spread (%)	No. of trades (p.a.)	Trade size Mean ($)	Trade size Median ($)
British Assets	1.95%	1.56%	94	112,401	22,945
Scottish American	3.88%	2.89%	7	71,527	24,435
Fidelity Special Values	2.45%	2.10%	101	59,597	22,735
British Empire Securities	2.44%	2.19%	98	19,109	7,516
Fidelity European Values	3.45%	3.34%	70	51,169	12,843
Smaller Companies	5.94%	3.70%	119	126,204	25,418

Panel A reports the index to which each ELB is linked and its maturity date, issue date and market capitalization at issue and on average over the ELB's life. In parentheses we show the ELB's market capitalization as a proportion of the total assets of the issuer.
Panel B shows the quoted spread, effective spread, number of trades per year, and the mean and median trade size for each ELB, all averaged over the security's life.

volume data for every transaction over the entire life of each security from IPO to the end of 2001, together with the time of transactions. We also have daily bid and ask quotes collected from the Stock Exchange Daily Official List for the whole life of each security.

The ELBs are linked to one of three Financial Times–Stock Exchange (FTSE) equity indices: the All-Share, Europe ex-UK, and SmallCap ex-ICs. The All-Share represents some 99 percent by value of the entire UK equity market. The Europe ex-UK index covers large and mid-sized companies across Continental Europe. The SmallCap ex-ICs comprises All-Share constituents that rank below the top 350 companies, and excludes closed-end funds (known in the UK as ICs or investments companies).

We require index closing prices and intraday index levels. Since the latter are not published, we use tick data for three closely related FTSE indices: the FTSE 100 Share, Eurotop, and Mid-250 respectively. These three indices are used as a basis for futures trading. The FTSE 100 is almost perfectly correlated with the All-Share (the correlation of daily returns is 0.99); the Eurotop is highly correlated with the Europe ex-UK (the daily correlation is 0.96); and based on weekly returns for the more thinly traded indices, the Mid-250 has a substantial correlation with the SmallCap (0.91).

We match the exact time of an ELB transaction with the corresponding 100 Share, Eurotop, or Mid-250 index level at the same time. We then use these index levels to infer the level of each of the indices underlying the ELBs.[9] Due to the high correlation between the indices for which we have tick data and the ELB index returns, we expect this procedure to be very precise, especially for the All-Share index.

3. Pricing of Equity-Linked Bonds

We define the price premium or discount on an ELB as

$$D_{i,t} = \ln(P_{i,t}/M_{i,t}) \tag{1}$$

where $P_{i,t}$ is the transaction price of the ELB and $M_{i,t}$ is the estimated level of the underlying market index at the time of an ELB transaction. We define a positive value of $D_{i,t}$ as a premium and a negative value as a discount. All ELBs tend to trade at a price discount relative to the level of the underlying equity market index.

Some of the ELBs are relatively more liquid and exhibit smaller discounts. However, others trade at discounts that can be more than ten percent. Table II shows

[9] We apply the following procedure in order to estimate the underlying index level M_t^u at the time an ELB transaction takes place using the reference indices M_t^r (the 100 Share, Eurotop, and Mid-250): First, we compute the ratio of the closing prices of M_t^u and M_t^r, namely M_t^u/M_t^r. We then multiply the intraday level of M_t^r at the time when an ELB transaction takes place by this ratio obtained from the closing prices in order to get an estimate of the intraday level of the underlying index.

summary statistics for ELB prices that are equally weighted across all transactions and expressed as a percentage. In Panel A of Table II we split the dataset into two-year periods. We compute the mean discount for each equity-linked bond in each of these intervals, and over the research period as a whole. As can be seen in the table, trades are on average at a discount for all but one of the biannual intervals from the IPO to the end of the sample period.

The distribution of ELB discounts is shown in Panel B of Table II. Over the entire history of these securities, the mean (median) discount for the four ELBs based on the All-Share index is 1.64 (1.24) percent; and for the other two indices the discounts are 3.30 (2.72) percent and 8.65 (8.85) percent respectively. For ELBs as a whole, the mean and median discounts are 2.71 percent and 1.79 percent respectively. As can be seen from the right-hand column of Panel B, over three-quarters of all transactions are executed at a discount relative to the daily index closing price.[10]

Although it is informative to examine ELB transaction prices and their relationship to underlying value, this understates the return premium from investing in ELBs. In order to quantify the return premium, an investment in ELBs has to be compared to an index fund.[11] For this comparison, cost and fee differences between ELBs and index funds are relevant.

Bid-ask quotes are only indicative of the real bid-ask spread. In fact, we find that most transactions take place within the quoted spread. We therefore use transaction data in order to infer the effective bid-ask spread. The effective spread is estimated as twice the absolute difference between the transaction price and the mid-price computed from the bid and ask quotes (as shown in Panel B of Table I). Using these estimates we are able to compute an adjusted return premium, relative to an index fund, for each of the six ELBs.

An adjustment to the return premium has to be made to take cost differences into account between an ELB investment and an open-ended index fund. James (2000) reports costs to which a UK index fund investor is exposed, comprising a 0.5 percent transaction tax (stamp duty) on purchases, 0.15 percent annual cost of rebalancing within the index fund, a bid-ask spread of 0.5 percent,[12] and an annual

[10] There are several reasons why some of the ELB transactions are at a premium. As will be seen in Section 6, ELB prices tend to revert gradually toward their long-term fundamental value. Large and/or persistent purchasers can push ELBs to a premium and cause slow adjustments. One example is repurchases made by ELB issuers who spread their transactions over an extended period. The expectation of continuing buyer-initiated trades tends to push the price temporarily above the level of the underlying index. However, for third-party buyers, price premia do not necessarily translate into lower returns than an index fund, since the returns have to be adjusted for cost differences as shown below.

[11] Dimson and Marsh (1984) describe how the largest pension fund in the UK had already switched to indexation at the start of the 1980s. By the late 1980s index funds were marketed actively to retail investors in the UK (James, 2000).

[12] Returns can be attenuated through transaction costs triggered by incoming and departing investors and market-timers (Chordia, 1996). UK index funds usually have a bid-ask spread to protect

Table II. Summary statistics on ELB pricing 1989–2001

Panel A: Mean discount for all ELB transactions

Security	1989–90	1991–92	1993–94	1995–96	1997–98	1999–01	Total
British Assets	−1.43	−1.10	−0.16	−0.50	−0.43	−2.88	−0.97
Scottish American	−2.90	−4.14	−0.89	−2.06	−3.81	−5.48	−3.33
Fidelity Special Values				−2.58	−2.27	−5.03[a]	−2.24
Brit. Empire Securities				−0.93	−1.54	−3.26	−2.20
Fidelity European Values		1.52	−0.08	−5.33	−4.84	−5.37	−3.30
Smaller Companies					−8.06	−8.72	−8.65
Unweighted average	**−2.17**	**−1.24**	**−0.38**	**−2.28**	**−3.50**	**−4.96**	**−3.45**
Weighted average	**−1.55**	**−1.12**	**−0.14**	**−1.76**	**−2.87**	**−4.34**	**−2.71**

Panel B: Distribution of discounts for ELBs

All transactions	Index to which ELB is linked			All ELBs
	All-Share	Europe ex-UK	SmallCap ex-IC	
1st percentile	−9.12	−17.01	−17.20	−14.72
5th percentile	−6.13	−13.98	−14.19	−10.71
25th percentile	−3.28	−6.78	−10.88	−4.82
Mean	**−1.64**	**−3.30**	**−8.65**	**−2.71**
Median	**−1.24**	**−2.72**	**−8.85**	**−1.79**
75th percentile	0.01	0.70	−6.76	−0.07
95th percentile	2.03	4.40	−2.30	2.65
99th percentile	5.22	6.50	0.39	5.78

Panel C: Mean annualized return premium for ELBs

	British Assets	Scottish American	Fidelity Special Values	British Empire Securities	Fidelity European Values	Smaller Companies
Institutional investor	0.48	0.66	0.83	0.44	1.32	2.37
Retail investor	1.38	1.56	1.73	1.34	2.22	3.27

[a]This ELB was called in December 1999.
Panel A shows average premia or discounts for each ELB over two-year subperiods and over the entire life of the security.
Panel B shows the distribution of premia or discounts for each ELB category and for all securities.
Panel C shows the mean return premium for both an institutional and a retail investor as compared to buying an index fund. The return premium is based on Equation (2) and then annualized and adjusted for cost differences arising from management fees and rebalancing costs. All measures are equally weighted across all transactions and are expressed as percentages.

management fee. We carry out this analysis for both an institutional and a retail investor using a 0.1 percent and a 1 percent annual management fee respectively.[13] Apart from the bid-ask spread, ELB investors do not incur any of these costs, which apply solely to equity index funds.

There are differences between the timing of index and ELB cash flows. Dividends on the index are spread out over the year, but ELB coupons are paid semiannually. In principle, this might give rise to price deviations between ELBs and the underlying index. On the one hand, ELB coupons are received with a slight delay compared to stock dividends. On the other hand, whereas stock dividends are taxed immediately (so that investors receive only the net dividend), ELB coupons are paid gross of tax, and the latter is not paid until the end of the tax-year. Though close to neutral, the overall impact slightly favors the ELB holder. In addition, capital gains are for most investors exempt from tax at maturity of the ELB.[14]

In Panel C of Table II we estimate the illiquidity return premium. To do this we adopt a procedure motivated by Constantinides (1986) and Vayanos (1998). They argue that larger bid-ask spreads are accompanied by a lengthening of investors' holding periods, which gives rise to smaller illiquidity premia. We therefore assume that each ELB is held until maturity.

The ELB return premium can therefore be computed as

$$R_t = \ln\left(\frac{P_T}{P_t\left(1+0.5H_t\right)}\right) - \ln\left(\frac{M_T}{M_t\left(1+0.5H'_t+\mathfrak{T}\right)}\right) \tag{2}$$

where P_t is the price of the ELBs at time t, H_t and H'_t are the bid-ask spreads on the ELB and index fund respectively, M_t is the level at time t of the underlying market index, $\mathfrak{T}$ is the rate of transaction tax (stamp duty), and T is the maturity date of the bond. We ignore brokerage commissions, which are small.

For the ELB we use the half-spread $0.5H_t$ because the security is held until redemption. The index fund investor may have an investment horizon that does not coincide with the maturity date of the ELB. Instead of the full spread for the index fund benchmark, we use the half-spread $0.5H'_t$ for the index fund as well. (We are being conservative here: if we were to apply the full spread H'_t to the index fund,

investors from this. In the US, where open-ended funds do not usually have a bid-ask spread, index fund investors suffer an annual rebalancing cost averaging 0.485 percent (Elton et al., 2004).

[13] The above fees were charged by the UK market leaders during the sample period commencing in 1989. Toward the end of our sample period, the UK introduced exchange traded funds that are exempt from transaction taxes, have a low rebalancing cost, a small spread, and an annual fee of 0.35–0.5 percent. If they had been available throughout the period at this fee level, investors would have experienced a cost between the institutional and retail levels specified above for index funds.

[14] The dominant investor group, UK pension funds, does not pay tax on either stocks or bonds. For married couples, capital appreciation on security disposals is exempt from tax for annual capital gains of up to about $28,000. Personal holdings within an individual savings account or personal pension portfolio were completely exempt from capital gains tax. Differential tax of ELB and index fund holdings is therefore unlikely to be relevant for nearly all ELB holders.

the ELB return premium reported below would be larger.) At maturity $P_T = M_T$, so these two terms cancel in Equation (2) and all quantities necessary to compute R_t are known at the time when a transaction takes place. We compute R_t for each ELB transaction and the return premium is then annualized. After that, we add the annual management fee and annual rebalancing costs as mentioned above. The mean return premia for an institutional investor and a retail investor are shown in Panel C of Table II.

As can be seen from Panel C, an institutional investor who buys ELBs is able to earn a substantial return premium, varying between 0.48 percent and 2.37 percent per year. The equally-weighted average is 1.02 percent per annum. Retail investors are able to earn a larger return premium: between 1.38 percent and 3.27 percent annually, and an average of 1.92 percent.[15] The return premium is influenced by the savings in annual management fee and index fund rebalancing costs. Even if a proportion of ELB transactions took place at prices above the underlying index, investors who bought at that price would mostly still have earned a premium relative to an index fund.

If most ELB transactions were seller-initiated this might explain their price discount. In Table III we therefore divide our sample into buyer- and seller-initiated transactions and examine them separately. Since our database does not indicate trade direction we use the Lee and Ready (1991) algorithm, and designate a transaction as a buy or sell depending on whether it is closer to the ask or bid quote. If the transaction price equals the midquote, then the tick test is used to classify the transaction: a buy is assumed if the price is higher than the previous trade's price and a sell otherwise.

Table III reveals that for ELBs as a whole, there is a 50:50 split between seller-initiated and buyer-initiated transactions. The distribution of discounts for both trade directions shows that even buyer-initiated trades are typically executed at a discount. The last two lines of Panels A and B show the mean annualized return premium calculated as in Equation (2). A comparison of the return premia in Panels A and B indicates that they are not very sensitive to trade direction.

To summarize, even in the absence of adverse-selection or inventory-risk costs, lower liquidity is associated with substantial expected return premia. While these expected illiquidity return premia would be difficult to estimate directly for common stocks, equity-linked bonds provide strong evidence of a reward for investing in illiquid securities.

It is important to point out, however, that it would be difficult to create a perfect arbitrage to release the return premium. Since there are no futures contracts on each underlying index, an arbitrageur might use futures on a highly correlated alternative index (see Section 2). In order to obtain an arbitrage profit, an arbitrageur would have to buy ELBs and short the corresponding index futures from the current time until maturity of the ELB. Doing this would impose basis risk, "roll over" price

[15] This return premium is measured relative to a benchmark that is itself imperfectly liquid. The total reward for illiquidity, with a perfectly liquid investment as the benchmark, would be larger.

Table III. Analysis of buyer- and seller-initiated ELB transactions

Panel A: Buyer-initiated transactions

	Index to which ELB is linked			All ELBs
	All-Share	Europe ex-UK	SmallCap ex-IC	
Percentage of buyer-initiated trades	51.83	44.19	43.63	49.50
Distribution of discounts				
5th percentile	−4.49	−8.29	−12.35	−8.29
25th percentile	−1.84	−4.48	−9.96	−3.05
Mean	**−0.65**	**−1.08**	**−8.00**	**−1.37**
Median	**−0.53**	**−0.67**	**−8.17**	**−0.75**
75th percentile	0.47	2.61	−6.10	0.51
95th percentile	2.80	4.77	−1.79	3.78
Mean annualized return premium				
Institutional investor	0.48	1.19	2.31	1.33
Retail investor	1.38	2.09	3.21	2.23

Panel B: Seller-initiated transactions

	Index to which ELB is linked			All ELBs
	All-Share	Europe ex-UK	SmallCap ex-IC	
Percentage of seller-initiated trades	48.17	55.81	56.38	50.50
Distribution of discounts				
5th percentile	−7.11	−15.11	−14.22	−11.73
25th percentile	−3.97	−8.14	−11.04	−6.08
Mean	**−2.38**	**−5.11**	**−9.02**	**−3.73**
Median	**−2.06**	**−5.05**	**−9.20**	**−2.91**
75th percentile	−0.60	−1.23	−6.99	−0.85
95th percentile	1.81	2.82	−2.45	1.78
Mean annualized return premium				
Institutional Investor	0.63	1.50	2.40	1.51
Retail Investor	1.53	2.40	3.30	2.41

Panel A shows summary statistics for transactions that are classified as buyer-initiated.
Panel B shows the same statistics for seller-initiated transactions.
In each panel we report the proportion of trades that are initiated by the buyer or seller, the distribution of premia or discounts for each ELB category, and the mean annualized return premia computed in the same way as in Table II. All statistics are expressed as percentages.

uncertainty, and some hedging error for the cross-hedge, as well as transaction and monitoring costs. This would make it relatively difficult to create a long/short arbitrage position over a time horizon of several years. Nevertheless, an equity investor with a long holding horizon can invest in ELBs and earn the return premium relative to index funds.

4. Potential Explanations for Price Discounts

The closed-end fund literature suggests potential explanations for prices to deviate from fundamental value. Dimson and Minio-Paluello (2003) survey this literature. Many explanations simply cannot apply to the ELB discount: for example, inaccuracy in estimating underlying asset values, the present value of future management fees, premia for superior selection skills or discounts for churning, embedded tax liabilities, uncertainty about the date of open-ending or liquidation, and exposure to non-listed assets. Nevertheless, the characteristics of ELBs suggest that their discounts could be attributed to a number of factors. In this section we examine the following potential explanations: noise, default risk, call provisions, and closed-end fund sentiment.

If price discrepancies between ELBs and the underlying index are just noise the following should hold: First, one would expect them to average zero; second, they should dissipate quickly; and third, discounts between different ELBs should be uncorrelated. We have already shown that ELB price discounts do not average zero. In Section 6, we show that ELB discounts are significantly autocorrelated and revert slowly to the mean, and we find significant correlations between discounts on different ELBs. We reject the null hypothesis that the price differences between ELBs and the underlying index are simply noise. In the following paragraphs we therefore consider alternative explanations for the ELB discount.

Default risk could occur when ELB obligations are revalued in line with the index, while the assets of the closed-end fund issuer underperform the index. It follows that default risk is influenced by the correlation between a fund's gross asset value and the underlying index. The default premium can be valued using standard Black-Scholes (1973) option pricing theory. All of the closed-end funds that issue ELBs have well-diversified portfolios that closely track their benchmark index (which is the index the ELBs are linked to). The funds therefore have a correlation between asset value and the index which is always above 0.8, and a debt ratio (including the ELB) that has for every ELB and on each day been below 40 percent. Consequently, the estimated default premium is in every case negligible.[16] Even stronger evidence against default-based explanations for the discount

[16] The value of the option was calculated whenever a transaction in an ELB took place. The expiration of the option was set equal to the remaining life of the ELB for each transaction. After that the maximum option premium for all trades was obtained. This maximum was exceedingly small. As a robustness check, we calculated correlations and standard deviations using both 60 months and 104 weeks of rolling returns, with identical qualitative results.

comes from the fact that the ELBs are repayable immediately if the debt ratio exceeds a specified limit.[17] If the latter is breached, the ELB holders' investment is redeemed immediately. Default risk can therefore be rejected as the explanation for the discount.

Call provisions apply to ELB securities if there is an adverse change in taxation, a discontinuance in index calculation, or in some cases if less than 25 percent of the issue remains outstanding after a certain date. The call provisions further protect bondholders. Since ELBs are normally traded at a discount relative to their underlying value, the effect of immediate redemption at the current index level will be an immediate enhancement to the ELB's return. Therefore, the prospect of an early call should reduce the discount of a seasoned ELB, rather than increase it.[18] Call provisions, as implemented for existing ELBs, protect the ELB investor and are value enhancing. They cannot explain the discount on equity-linked bonds.[19]

If ELBs are priced in the same way as closed-end funds, then their discounts should be related to closed-end fund discounts. In Section 7 we regress ELB discounts on underlying index returns, as well as changes in the average UK closed-end fund discount. The residuals from this regression reveal that closed-end fund behavior has at best a marginal impact on ELB discounts. Deviations between ELBs and the underlying index are not materially explained by fluctuations in closed-end fund discounts.

To sum up, we find that ELBs tend to trade at a persistent discount relative to the underlying index. There is firm evidence that ELB discounts are real and not an artefact of our estimation procedure. Noise, default risk, call provisions and closed-end fund sentiment do not explain this phenomenon. We attribute the finding that ELBs have a lower price than the underlying index to their illiquidity.

5. Liquidity

In order to examine the role of liquidity more formally, we carry out cross-sectional and time series regressions of ELB discounts on factors that proxy for illiquidity. In this section we focus on cross-sectional relationships; in later sections we turn

[17] As an example, the listing particulars of the Scottish American Investment Company contain the following provisions: "*If the ratio of moneys borrowed by the Company and its Subsidiaries (exclusive of intra-group borrowings) to the Adjusted Total of Capital and Reserves calculated as at any Interest Calculation Date shall be more than 1:2 then the Trustees shall be obliged . . . to declare the Stock to have become immediately repayable*". Since the redemption takes place at the current level of the underlying equity index, whereas ELBs trade at a discount, early redemption results in an immediate uplift in the return to ELB holders.

[18] The only case of an early call was in December 1999 when the Fidelity Special Values ELB was called by its issuer due to a change in UK tax laws. The tax change amounted to discontinuance of the index in its existing format to which the bond was linked. The effect of immediate redemption at the current level of the equity index was an unanticipated windfall gain to ELB stockholders.

[19] Under certain conditions, ELB holders also have the right to redeem their securities early given three months' notice. However, the conditions for early redemption have so far never been satisfied, and early redemption has never been initiated by security holders.

to more detailed time-series estimation. To explore the cross-sectional relationship between underlying factors and ELB discounts, one could in principle pool the data for all the ELBs. To gain greater insight into the cross-sectional relationship, however, we use Fama-MacBeth regressions of price discounts on bid-ask spreads (the number of explanatory variables is constrained by data limitations).[20]

The regression is carried out for each period when ELBs traded contemporaneously, and t-statistics are computed for the time series of Fama-MacBeth (1973) regression coefficients. Consistent with their attributes of being illiquid securities, there are no occurrences when all six securities trade on the same day. Therefore, we aggregate the data and construct a weekly time series for each ELB using the last transaction of every week. Converting the data in this way we are still left with only one week when all ELBs trade. We therefore omit the two securities with the lowest number of transactions, Scottish American and Smaller Companies, which leaves us with 74 weeks when all the remaining four securities trade. For the 74 weeks for which we have four different ELB transactions we carry out the following cross-sectional regressions:

$$D_{i,t} = \alpha_t S_{i,t} + \beta_t H_{i,t-1} + \varepsilon_t \tag{3}$$

where $D_{i,t} = \ln(P_{i,t}/M_{i,t})$ measures the difference between the ELB price $P_{i,t}$ and the contemporaneous (intraday) level of the underlying market index $M_{i,t}$ obtained for the time of an ELB transaction. $H_{i,t-1} = \ln(P^{ask}_{i,t-1}/\ P^{bid}_{i,t-1})$ is the effective bid-ask spread for the previous week. Instead of a constant, to control for the bid-ask bounce, we use a bid-ask switching dummy $S_{i,t}$ which is obtained using the Lee and Ready (1991) algorithm described in connection with Table III. The dummy variable $S_{i,t}$ is equal to either $+1$ or -1 if a trade is classified as a buy or a sell respectively.

We measure the spread $H_{i,t-1}$ for the first week of our 74-week sample and then, following Fama and MacBeth (1973), use this estimate in the cross-sectional regression in the second week. We then update the spread measures and use the updated figures for the next cross-sectional regression in the third week, and so on. While we only have four observations in each cross-sectional regression, which leaves us with only two degrees of freedom, we are able to run the regression 73 times. This provides us with a time series of regression parameters α_t and β_t for which we are able to compute standard errors and t-statistics, adjusted for autocorrelation using the Newey-West (1987) procedure. The regression coefficients (t-statistics in parentheses) are as follows: $\alpha_t = 0.001$ (3.12) and $\beta_t = -0.43$ (-2.23), with a mean adjusted $R^2 = 21.34\%$. Of the estimated β_t coefficients,

[20] Also, in contrast to the analysis to be presented in Section 6, we regress the level of discounts on the level of spreads. This emphasizes the cross-sectional nature of the link between return premia and illiquidity. We have also carried out the cross-sectional regressions in changes. While t-statistics tend to be somewhat lower, they are still significant at conventional significance levels and our qualitative conclusions remain unchanged.

79.5 percent are negative, and the mean of β_t is statistically significant at the 5 percent level. Since β_t is negative, the discount widens for a higher bid-ask spread.

In addition, we run Fama-MacBeth regressions with quoted rather than transaction prices. We have quotes for every trading day for each ELB, even when there was no transaction. Using quote data enables us to increase our sample size considerably both over time and cross-sectionally. A possible drawback of this data is that quotes are not always updated promptly, and therefore doubts remain about how representative quotes are of the true (but unobservable) market values of ELBs. However, since we are using only firm quotes, dealers are obliged to trade at these prices, except in unusual market circumstances. Moreover, unlike transaction prices, midquotes are free of bid-ask bounce, so we do not have to control for this effect. Dealers have to update quotes relatively frequently since a number of large institutional investors hold a significant proportion of ELBs which they have to mark to market. Therefore, these investors insist on timely quote revisions. An extreme example of this is the ELB issued by the Scottish American Investment Trust. Approximately 70 percent of this ELB is held by Barclays Global Investors who require the dealers' quotes to be current.[21]

We regress the ELB price discount computed as the difference between the midquote at the close of the market for day t and the index closing price on the previous day's quoted spread. Hence, the regression model is as follows

$$D^q_{i,t} = \alpha_t + \beta_t H^q_{i,t-1} + \varepsilon_t \tag{4}$$

where $D^q_{i,t} = \ln(P^q_{i,t}/M^c_{i,t})$ which measures the difference between the ELB midquote $P^q_{i,t}$ and the closing price of the underlying market index $M^c_{i,t}$ on date t. $H^q_{i,t-1} = \ln(P^{ask,q}_{i,t-1}/\, P^{bid,q}_{i,t-1})$ is the bid-ask spread for the previous day. Here α_t is simply a constant rather than a bid-ask switching dummy. We run this regression for all five ELBs for which a long sample-history is available (omitting the Smaller Companies ELB), which results in a sample covering 1028 days. The regression coefficients (t-statistics, adjusted as before for autocorrelation, in parentheses) are as follows: $\alpha = 0.005$ (0.26) and $\beta_t = -0.16$ (-2.64) with a mean adjusted $R^2 = 16.21\%$. Of the estimated coefficients, 82.2 percent are negative, and the mean of the β_t is again statistically significant at the 5 percent level. In other words, when the bid-ask spread is higher, investors require a larger expected return, ELB prices drop, and the discount widens.

6. Time Series Analysis

We now examine the time series of ELB discounts and link variation in the discount, or equivalently variation in the expected return premium, to a number of

[21] Information on ELB ownership and institutional investors' strategy was obtained through personal interviews with investment managers.

market variables. The period covered runs from the first IPO of an ELB in 1989 to the end of 2001.

In the first set of regressions we relate the time series of discount changes ΔD_k for each ELB to variables that represent variation in the return premium that investors require as a compensation for illiquidity. The time series comprises the sequence of days on which an ELB trade occured, using the last transaction of the day for each ELB. The gaps between each transaction date are therefore of varying duration and lagged terms are calculated as follows: lag $j = 1$ represents the interval from the preceding trade to the most recent trade, lag $j = 2$ represents the interval from two trades ago to the preceding trade, and so on. In the time-series analysis we exclude the ELB issued by the Scottish American closed-end fund, since we have too few transactions for this security.

6.1. MEASURES OF ILLIQUIDITY

We use the following variables to explain the discounts of our sample of ELBs:

- ΔD_{k-j} : Five lags of discount changes ($j = 1, 2, \ldots, 5$) where the price discount D_k is expressed in natural logarithm terms as above.[22] If ELBs were highly liquid, any deviation from fundamental value would reverse promptly: the speed of reversion to fundamental value would be high, implying a negative regression coefficient for lagged discount changes that is close to one for the first lag. Illiquidity would be revealed by slow mean reversion over an extended period, similar in spirit to Klibanoff, Lamont, and Wizman (1998), implying lagged discount changes with a negative coefficient well below one.
- S_k^b, S_{k-1}^b : One contemporaneous term and one lagged term of a dummy variable which is equal to $+1$ if transaction k is buyer initiated and zero otherwise.
- S_k^s, S_{k-1}^s : One contemporaneous term and one lagged term of a dummy variable which is equal to +1 if transaction k is seller-initiated and zero otherwise. S_k^b, S_k^s and their lagged terms are used to isolate the impact of bid-ask bounce on the dependent variable. Since transaction data are used and ELB spreads are wide, the discount should reflect whether trades are buyer- or seller-initiated. The higher is the coefficient for these variables, the higher is the impact of the spread on transaction prices – a sign of low liquidity. Since the dependent variable is measured in changes, lagged effects are included.
- V_k, V_{k-1} : One contemporaneous and one lagged term of the natural logarithm of the volume for each day. Volume is defined as the price in currency units

22 While the price discount might be expected to vary with the maturity of these securities, we have found this to be a second-order effect empirically, in particular because we are carrying out our time-series regressions with changes in the price discount as the dependent variable. It is important to note that we are actually using relative changes rather than absolute changes since ΔD is a first difference of discounts measured in natural logarithms, and therefore $\Delta D = \ln\{(P_{i,t}/M_{i,t})/(P_{i,t-1}/M_{i,t-1})\}$. Although the level of the discount may alter as the security reaches the end of its life, the short-term relative change in the discount is largely unaffected by maturity.

times the number of securities traded. To alleviate the influence of outliers, volume is truncated at the 99th percentile. The volume is interacted with the bid-ask spread dummy variables in order to relate the price impact of a transaction to its size. Buyer-initiated transactions tend to raise ELB prices and narrow the discount; seller-initiated transactions tend to depress ELB prices and widen the discount. The larger a transaction, the higher its impact is expected to be. The sign and magnitude of the regression coefficients for the volume variables, interacted with the bid-ask dummies, are the per-unit volume impacts on the conditional mean of the dependent variable. Moreover, these coefficients measure the persistence of the price impact.[23] Since the dependent variable is measured in changes, lagged volume is included.

– ΔH_{k-1} : The lagged change in the effective bid-ask spread. Investors require a larger compensation if trading costs are high. Therefore, after observing the bid-ask spread for a transaction, market participants can be expected to revise their expectations of trading costs for the following and subsequent transactions. Simultaneously, they would be expected to revise their required return; so if the spread increases, we expect the price discount to widen subsequently.
– $\sigma_{m,k-1}$: Market volatility measured by the size of the previous day's trading range of the underlying equity index in natural logarithm terms.[24] Hence, $\sigma_{m,k-1} = \ln(M^h_{k-1}/M^l_{k-1})$ where M^h_{k-1} and M^l_{k-1} are the daily high price and low price for the underlying equity index respectively. Glosten (1987) and Hasbrouck (1988) provide evidence linking the volatility of price changes to trading costs, and hence to the illiquidity discount. A lagged volatility term is used because investors are expected to update their beliefs about the future based on current volatility.
– $\overline{Q}_k$: A non-parametric measure of the correlation between ELB discount changes. For each ELB, we regress $\Delta D_{k,i}$ on the bid-ask switching dummy $\Delta S_{k,i}$, where $S_{k,i}$=+1 or −1 depending on whether transaction k is buyer- or seller-initiated. For each ELB we use regression residuals $\Delta \widetilde{D}_{k,i}$ purged of bid-ask bounce. If security $l \neq i$ trades between transactions $k-1$ and k of security i, then we attribute to security l the value $Q_{k_i,l} = +1$, 0 or −1 depending on whether $\Delta \widetilde{D}_{k,i}$ is positive, zero, or negative. We compute the cross-sectional average $\overline{Q}_{k_i,l}$ for each transaction k in security i.[25] A signi-

[23] A relation between trading volume and prices is also predicted by several information-based models of trading, such as Easley and O'Hara (1987). However, for ELBs there cannot be any superior information about the fundamental value of the security which is just the underlying index value. The only type of superior information that may exist for ELBs is information about the order flow.

[24] The daily trading range for the underlying index is estimated in the same way as the intraday index levels, as described in footnote 9.

[25] The subscript k_i emphasizes that this correlation variable differs for each security i. Use of a non-parametric measure alleviates the impact of nonsynchronicity between ELB and index transactions. However, indices themselves suffer from a stale price problem for their individual components that leads to spurious return autocorrelations. The resulting measurement errors in the discounts may

ficant correlation between discount changes of different ELBs is a necessary condition for the existence of a systematic component to liquidity risk.[26]

Table IV reports summary statistics for the transaction data and the explanatory variables. It shows that, with the exception of British Assets, the proportion of trades that are transacted at a price below the midquote (which we classify as seller-initiated) is slightly higher than the proportion of trades above the midquote (classified as buyer-initiated). While seller-initiated trades tend to be slightly larger than buyer-initiated transactions, average trade sizes – whether based on the mean or the median – are similar for both types of trades. The final section of Table IV shows the time between successive days in which a trade takes place, Δt_k. This confirms the infrequency of trading in these securities and also reveals that there is considerable variation in each ELB's time between trades.

6.2. THE IMPACT OF ELB ILLIQUIDITY

Changes in ELB discounts are analyzed using a regression with the explanatory variables described above. Regression (5) is carried out separately for each ELB, except Scottish American, as well as on a pooled basis using a random effects, panel data model. To control for heteroskedasticity in the residuals, due to unequal trading intervals, the conditional variance of the dependent variable is regressed on the number of days between trades. The estimation is done using maximum likelihood.

$$\begin{aligned}\Delta D_k \;=\; & \sum_{j=1}^{5} \beta_j \Delta D_{k-j} + \beta_6\{S_k^b \cdot V_k\} + \beta_7\{S_{k-1}^b \cdot V_{k-1}\} + \beta_8\{S_k^s \cdot V_k\} \\ & + \beta_9\{S_{k-1}^s \cdot V_{k-1}\} + \beta_{10}\Delta H_{k-1} + \beta_{11}\sigma_{m,k-1} + \beta_{12}\overline{Q}_k + \varepsilon_k \qquad (5)\end{aligned}$$

Most of the independent variables in Equation (5) measure the extent to which an ELB is illiquid or exposed to (seller-initiated) price pressure. These variables include lagged discount changes, ΔD_{k-j}, seller-initiated volume, $S_k^s \cdot V_k$ and $S_{k-1}^s \cdot V_{k-1}$, changes in the bid-ask spread, ΔH_{k-1}, and index volatility, $\sigma_{m,k-1}$. So for example, if the bid-ask spread increases, then we would expect the ELB price discount to become even more negative. For these variables, we therefore hypothesize that the slope coefficients will be negative.

The remaining independent variables in Equation (5) measure jumps in the volume demanded, $S_k^b \cdot V_k$ and $S_{k-1}^b \cdot V_{k-1}$, and the tendency of an ELB price discount to comove with other discounts, $\overline{Q}_k$. In contrast to the other slope coefficients we hypothesize that β_6, β_7 and β_{12} are positive.

be correlated across ELBs, at least for those based on the same index. This applies to four of the six ELBs, which are linked to the daily FTSE All-Share Index. The autocorrelation of the latter over the last twelve years is, however, only 0.057. It seems likely that index autocorrelation has a negligible impact on the nonparametric correlation measure $\overline{Q}_k$.

[26] In order to investigate whether the ELB liquidity component is also correlated with aggregate risk, we regress ELB discount changes on market-wide proxies for liquidity in Section 7 below.

Table IV. Summary statistics for transaction data

Variable	British Assets	Fidelity Special Values	British Empire Securities	Fidelity European Values	Smaller Companies
Low price (GBP)	0.90	14.45	1.67	0.97	1.67
High price (GBP)	3.24	31.00	3.15	3.40	3.23
% trade at prices:					
> Midquote	52.19%	43.49%	42.67%	42.28%	40.52%
= Midquote	9.46%	4.60%	3.83%	3.19%	5.18%
< Midquote	38.35%	51.92%	53.50%	54.53%	54.31%
Trade size (buyer-initiated)					
Mean	$111,733	$60,540	$17,990	$49,007	$124,787
Median	$22,258	$23,394	$7,019	$9,365	$24,721
Std. dev.	$326,362	$195,044	$44,056	$247,287	$260,512
Trade size (seller-initiated)					
Mean	$114,274	$57,786	$20,023	$52,880	$127,277
Median	$23,687	$22,459	$8,146	$17,778	$25,732
Std. dev.	$303,790	$202,434	$29,162	$125,048	$292,731
Signed log of volume, $S_k \cdot V_k$					
Mean	0.9591	−0.9582	−0.8481	−0.9087	−1.5502
Std. Dev.	6.7181	6.2811	6.8221	7.2821	5.8321
Effective bid-ask spread, H_k					
Mean	0.0156	0.0210	0.0219	0.0334	0.0337
Std. dev.	0.0262	0.0223	0.0243	0.0331	0.0311
Log index trading range, $\sigma_{m,k-1}$					
Mean	0.0105	0.0119	0.0127	0.0112	0.0121
Std. dev.	0.0069	0.0083	0.0086	0.0088	0.0092
Correlation variable, Q_k					
Mean	0.061	0.130	0.088	0.092	0.013
Std. dev.	0.626	0.668	0.699	0.725	0.604
Time between trades, Δt_k					
Mean	3.88	3.63	3.74	5.20	3.08
Std. dev.	5.72	6.74	4.79	8.57	5.48

Summary statistics are presented for transaction prices and explanatory variables. The variables are defined in the first part of Section 6. The sample consists of all ELBs except Scottish American. All statistics are based on the last transaction of each day with trading activity.

Assuming prices follow geometric Brownian motion, the conditional return variance is related linearly to the length of the return period. Since unequally spaced observations are a potential source of heteroskedasticity we follow Hausman et al. (1992) and parametrize the conditional variance as $\sigma_k^2 = \gamma_0 + \gamma_1 \Delta t_k$ where the time in days between ELB transactions, Δt_k, is used as an explanatory variable for the conditional variance of the dependent variable σ_k^2.

The regression results are shown in Table V.[27]

As expected, the coefficients for the lagged discount change ΔD_{k-j} are negative at all lags across all securities. ELB prices tend to revert gradually toward their long-term fundamental value. However, the coefficient for the first lag $\widehat{\beta}_1$ is in all cases below 1.0 and is in almost every case below 0.5, while most lagged coefficients are highly significant up to the fifth lag. This demonstrates that for any deviation from their long-term fundamental value it takes at least five lags to revert to that level.[28] Hence, these securities can for long periods trade at prices that will, after days or weeks, revert towards their long-term mean discount.

Discussion with ELB traders suggests that prices are influenced by market awareness of institutional buying or selling activity. Because of the infrequency of ELB trading, large investors are obliged to spread their trading over a lengthy period. This reinforces the tendency for prices to revert only gradually toward their long-term value. These are symptoms of marked illiquidity that are not witnessed among options, futures, ETFs, and other index derivatives that are traded in high volume on liquid markets. Despite the ease of estimating the intrinsic value of ELBs, they often trade at relative prices that are unlikely to be sustained.

The bid-ask dummy variables, interacted with ELB volumes, $S \cdot V$, are mostly statistically significant and all are of the expected sign. We use these compound variables to classify a transaction as buyer- or seller-initiated. This reveals whether, in addition to the overall price impact of trades, prices are largely dominated by trades on one side of the market. We have already seen that seller-initiated trades tend to be slightly larger than buyer-initiated transactions, and might therefore have a larger impact. However, Table V shows that, for the sample as a whole, the absolute values of $\widehat{\beta}_6$ and $\widehat{\beta}_8$ are almost identical. There is no indication that price discounts are a result of seller-initiated transactions.

Investors need to be compensated for higher expected trading costs by a larger expected return and therefore a lower price. We therefore expect ELB discounts to be more negative when the lagged bid-ask spread H_{k-1} is larger, and vice versa. Consistent with this, all regression coefficients $\widehat{\beta}_{10}$ are negative, though not all are statistically significant. The results suggest that investors are more sensitive to

[27] Recall that if there were several ELB transactions per day, only the last trade of the day is used in the regression model.

[28] Using the mean time between trades from Table IV, we can approximate the interval that corresponds to five lagged discount change terms. The average number of days represented by the first five lags are as follows: British Assets: 19, Fidelity Special Values: 18, British Empire Securities: 19, Fidelity European Values: 26, and Smaller Companies: 15.

Table V. Separate and pooled regressions on illiquidity attributes

Coefficient	British Assets	Fidelity Special Values	British Empire Securities	Fidelity European Values	Smaller Companies	Pooled regression
$\beta_1 : \Delta D_{k-1}$	−0.2933	−0.2438	−0.5337	−0.3062	−0.3573	−0.3755
	(−16.9)	(−9.8)	(−20.2)	(−8.8)	(−10.0)	(−38.6)
$\beta_2 : \Delta D_{k-2}$	−0.1351	−0.1786	−0.1645	−0.2142	−0.1388	−0.1645
	(−6.4)	(−6.3)	(−6.3)	(−6.1)	(−3.1)	(−15.6)
$\beta_3 : \Delta D_{k-3}$	−0.0909	−0.0652	−0.0998	−0.0905	−0.1279	−0.0975
	(−3.6)	(−1.8)	(−3.3)	(−2.4)	(−3.5)	(−8.7)
$\beta_4 : \Delta D_{k-4}$	−0.1069	−0.0240	−0.1911	−0.0524	−0.0544	−0.0952
	(−5.5)	(−0.7)	(−6.1)	(−1.4)	(−1.4)	(−8.4)
$\beta_5 : \Delta D_{k-5}$	−0.0722	−0.1036	0.0081	−0.0217	−0.0648	−0.0221
	(−4.2)	(−3.4)	(0.3)	(−0.6)	(−1.8)	(−2.1)
$\beta_6 : S_k^b \cdot V_k$	0.0007	0.0005	0.0016	0.0034	0.0011	0.0010
	(5.6)	(1.2)	(4.4)	(3.8)	(0.9)	(5.8)
$\beta_7 : S_{k-1}^b \cdot V_{k-1}$	0.0001	0.0003	0.0006	0.0001	0.0006	0.0002
	(1.5)	(1.6)	(3.2)	(0.6)	(1.2)	(3.2)
$\beta_8 : S_k^s \cdot V_k$	−0.0008	−0.0017	−0.0012	−0.0005	−0.0030	−0.0011
	(−7.2)	(−4.5)	(−3.4)	(−0.6)	(−1.9)	(−6.6)
$\beta_9 : S_{k-1}^s \cdot V_{k-1}$	−0.0001	−0.0006	−0.0003	−0.0001	−0.0001	−0.0001
	(−2.3)	(−0.8)	(−2.1)	(−0.8)	(−0.8)	(−3.0)
$\beta_{10} : \Delta H_{k-1}$	−0.0009	−0.0006	−0.0011	−0.0004	−0.0029	−0.0010
	(−1.2)	(−1.8)	(−1.4)	(−2.6)	(−2.9)	(−1.9)
$\beta_{11} : \sigma_{m,k-1}$	−0.0003	−0.0004	−0.0008	−0.0003	−0.0010	−0.0004
	(−1.1)	(−2.5)	(−0.9)	(−2.1)	(−1.9)	(−1.7)
$\beta_{12} : \overline{Q}_k$	0.0011	0.0006	0.0002	0.0021	0.0025	0.0006
	(3.1)	(1.6)	(1.0)	(1.4)	(1.8)	(2.5)
γ_0 : *Intercept*	0.0103	0.0127	0.0183	0.0242	0.0210	0.0173
	(66.9)	(38.1)	(37.4)	(30.6)	(29.7)	(105.2)
$\gamma_1 : \Delta t_k$	0.1503	0.1400	0.0777	0.0436	0.0953	0.0861
	(15.9)	(11.2)	(6.2)	(5.1)	(4.6)	(19.2)
Adjusted R^2	31.39%	26.91%	46.62%	23.15%	19.88%	26.92%
Number of obs.	1162	521	599	595	366	3243

Coefficients are shown for regression (5) of ELB discount changes ΔD_k on security-specific explanatory variables. The following explanatory variables are used: ΔD_{k-j} five lags of discount changes ($j = 1, 2, \ldots, 5$); S_k^b, S_{k-1}^b one contemporaneous term and one lagged term of a dummy variable which is equal to $+1$ if transaction k is buyer-initiated and zero otherwise; S_k^s, S_{k-1}^s one contemporaneous term and one lagged term of a dummy variable which is equal to $+1$ if transaction k is seller-initiated and zero otherwise; V_k, V_{k-1} one contemporaneous and one lagged term of the natural logarithm of the volume for each day; ΔH_{k-1} the lagged change in the effective bid-ask spread; $\sigma_{m,k-1}$ market volatility measured by the logarithm of the previous day's index trading range; $\overline{Q}_k$ a non-parametric measure of the correlation between ELB discount changes. We use the last transaction of each day with trading activity, so to adjust for heteroskedasticity the conditional variance of the dependent variable is regressed on the number of days between trades, Δt_k. The sample is the same as in Table IV.

changes in expected trading costs for securities that have higher spreads, as can be seen for the ELBs issued by Fidelity European Values and Smaller Companies which show significant t-statistics.

Higher market volatility increases execution risk. For illiquid securities investors may have to delay to achieve a reasonable price. In the presence of higher execution risk investors demand a larger price discount. In addition, dealers may also want to be compensated for their higher risk.[29] We seek to capture this relationship using lagged index volatility, $\sigma_{m,k-1}$. We expect the discount to be more negative if market volatility is high, which is confirmed by our results. All coefficients $\widehat{\beta}_{11}$ for this variable are negative, though only two are significant. The evidence is consistent with the view that investors require higher illiquidity premia when market volatility increases.

Are fluctuations in illiquidity purely idiosyncratic, or is there a systematic component to illiquidity? A high-frequency systematic component has previously been identified among equities (Chordia et al., 2000; Hasbrouck and Seppi, 2001), but an unanswered question is whether liquidity is strongly correlated among low-cap securities and over longer intervals. If so, then illiquidity cannot be diversified away, and should be a priced risk factor. The prices of illiquid assets would be further depressed by uncertainty about their future illiquidity. Our nonparametric measure of correlations between ELB discount changes $\overline{Q}_k$ gives rise to a positive coefficient for every security, and for the pooled sample it is significant at the 5 percent level. Despite the ad hoc nature of our correlation variable, this finding indicates systematic comovement in illiquidity which is consistent with the higher-frequency evidence cited above.

As mentioned earlier, we do not have equally spaced observations so we parameterize the conditional variance as a function of the interval between trades. As can be seen from Table V, the adjustment for heteroskedasticity is highly significant for every security as well as for the pooled regression.

To summarize, discounts revert slowly to their long term mean level and price impact functions are significantly upward sloping (i.e., prices are sensitive to trade size). Changes in ELB discounts are significantly positively related to lagged changes in bid-ask spreads and return volatility. This reinforces the conclusion that ELB prices are driven by illiquidity, which is found to be correlated across securities.

7. Other Proxies for the Illiquidity Premium

We now investigate whether there is a market wide component of variations in liquidity that affects financial assets in general. To do this, we test whether the ELB discount is related to factors previously identified as liquidity measures and

[29] However, inventory holding costs are very minor here because of the low hedging error. There should only be a relation to the extent that dealers do not hedge their ELB positions. In that case, higher index volatility leads to higher risk for dealers.

indicators of the illiquidity return premium. We show that there is significant co-movement between our direct measure of the ex ante illiquidity return premium and other variables that measure the expected rewards from less liquid investments or are proxies for market-wide liquidity.

We use six measures of the expected illiquidity premium that pre-date our own study:

– *Small*, the small-cap premium. This is defined as the logarithmic small-cap equity index return minus the logarithmic large-cap equity market return. Stoll and Whaley (1983) and Dimson et al. (2003) link trading costs, and hence illiquidity, to the small-cap premium. As small stocks tend to be relatively less liquid, their returns should contain a premium that compensates investors for higher trading costs. As a result, we expect a positive relation between this liquidity proxy and the expected illiquidity return premium on ELBs. As the expected return premium on less liquid small stocks increases, the expected return premium on ELBs that are similarly illiquid should increase as well, in the presence of a systematic component to liquidity.
– *Discount*, the change in the closed-end fund discount.[30] This is defined as the average closed-end fund index logarithmic return minus the constituents' net-asset-value logarithmic return. Lee, Shleifer and Thaler (1991) relate performance of less liquid securities to the closed-end fund discount, while Malkiel (1977) finds that although fund discounts cannot be explained by illiquidity alone, exposure to illiquid assets influences fund discounts. As above for the small-cap premium, we expect a positive relation between this liquidity proxy and the expected return premium on ELBs.
– *Maturity*, the change in the bond maturity premium. This is defined as the logarithmic long bond index total return minus the logarithmic Treasury bill return. Longstaff (2000) reviews the linkages between the demand for liquidity in asset markets and the maturity premium. Due to their longer time to maturity, long-term bonds are less liquid than bills. Again, investors should be compensated for lower liquidity with higher returns. As a result we expect this factor to be positively correlated with ELB discount changes.
– *Turnover*, the change in market volume. Market volume is measured as the natural logarithm of UK stock market turnover. First differences of this measure are used. Both time-series and cross-sectional models underpin the linkage between asset returns and trading volume; see Amihud and Mendelson (1986, 1991), Karpoff (1987), Baker and Stein (2002), and Datar et al. (1998). As trading volume increases, it becomes easier for an investor to transact a given quantity of a security, and immediacy (the waiting time until a transaction occurs) improves. Simultaneously, direct trading costs (bid-ask spreads) are likely to decrease when volume increases. That is, price discounts should

[30] ELB pricing is not just a reflection of closed-end fund discounts. Nevertheless, since closed-end fund discounts might partially be attributed to illiquidity, we may expect a limited relationship between ELB pricing and closed-end fund pricing.

become less negative, since investors require a smaller reward for illiquidity when the market becomes more liquid. In the presence of a systematic liquidity component we therefore expect a positive relation between market volume and ELB discount changes.

- *Credit*, the corporate bond return premium over a Treasury bond index. This is calculated as a corporate bond index logarithmic total return minus a duration-matched Treasury index logarithmic total return. Duffie and Singleton (1997) and Huang and Huang (2000) stress the link between credit spreads and liquidity. Securities that have higher credit risk also tend to be less liquid. Therefore, the difference between corporate bond returns and Treasury returns is not only a reward for credit risk, but also a compensation for lower liquidity. When the credit spread widens, which can partly be attributed to greater illiquidty in bond markets, ELB price discounts may be expected to widen as well.
- *Futures*, the change in the futures basis (the spot minus the futures price) for the FTSE 100 futures contract. Chen et al. (1995) provide the justification for regarding the basis as a measure of stock market liquidity. Futures incur considerably lower transaction costs than the underlying securities. Volume in the futures market is also substantially higher than in the spot market. Therefore, the futures basis can be regarded as partly due to liquidity. Consequently, changes in the futures basis should be positively related to changes in ELB price discounts if a common liquidity component exists.

We use the last transaction of every week for each ELB since several of our market-wide liquidity proxies are only available on a weekly basis. We carry out a pooled regression for all ELBs in a random effects, panel data model. As in the previous section, Δt_k is used as an explanatory variable for the conditional variance of the dependent variable, σ_k^2, as an adjustment for heteroskedasticity. The regression model is as follows:

$$\begin{aligned}\Delta D_k \; = \; & \sum_{j=1}^{5} \beta_j \Delta D_{k-j} + \beta_6\{S_k \cdot V_k\} + \beta_7\{S_{k-1} \cdot V_{k-1}\} + \delta_1 Small_k \\ & + \delta_2 Discount_k + \delta_3 Maturity_k + \delta_4 Turnover_k + \delta_5 Credit_k \\ & + \delta_6 Futures_k + \varepsilon_k \qquad (6)\end{aligned}$$

All six market factors are orthogonalized against the contemporaneous index return and the first five lags in order to ensure that they are not simply capturing variability in the dependent variable due to comovement with the underlying index.[31] The drawback of this procedure is that the regression coefficients for

[31] We check for cross-correlations between the resulting six orthogonalized series, and all are considerably below 0.2. This indicates that we do not obtain artefactual t-statistics because of multicollinearity between the explanatory variables.

the orthogonalized variables do not have a straightforward economic interpretation but, on the other hand, the orthogonalization is a safeguard against spurious interpretation.[32]

Table VI reports the regression results from Equation (6). There is a relationship in the direction we hypothesize between our direct measure of the ex ante illiquidity premium and the six proxies described above. Whether the latter are incorporated into the model singly or in combination, most are significant at the 5 percent level. As can be seen from the R^2 in the bottom row of Table VI the market-wide liquidity proxies add about 2-3 percent explanatory power. This is consistent with the view that the ex ante reward for illiquidity revealed in our study is captured, at least partially, by proxies for the illiquidity premium that have been suggested in previous studies.

8. Conclusion

Equity-linked bonds provide a unique opportunity for measuring the price of illiquidity in the equity market because they exhibit two key features: First, there is no superior information concerning the fundamental value of the security and there can therefore be no adverse selection costs. Second, since ELBs have no specific risk component, and market exposure can easily be hedged, market maker inventory costs are negligible. Fixed clearing costs remain as a factor that can influence the price of illiquidity.

We find strong evidence that there is an economically significant expected return premium associated with illiquidity. Unlike other studies of traded equities, we are able to measure the illiquidity return premium on an ex ante basis. Since ELBs have exposure only to their underlying index, we obtain a clean measure of the return premium and do not have to assume a particular asset pricing model. These higher expected returns are not only sufficient to compensate investors for larger bid-ask spreads, but remain statistically and economically significant after accounting for cost differences between ELBs and an index fund. The existence of clearing costs may reduce security prices by more than the amount that dealers extract from the market.

Even in the absence of asymmetric information and with negligible inventory holding costs, illiquidity depresses asset prices and therefore increases expected security returns. Using our time-series data, spanning over a decade, we find that ELB prices revert slowly to their long term mean, with prices that are sensitive to trade size. Discounts widen when spreads and volatility are high. Since the cash

[32] Since some of our market-wide proxies for illiquidity are only available at weekly frequency we use the last transaction of each ELB in every week to compute ΔD as opposed to the daily discount changes used in Section 6. Therefore, the number of observations used for each ELB is reduced. Since we do not want to consume too many degrees of freedom in our regression we only use the two most important control variables from Section 6 (i.e., current and lagged signed volume) as control variables here.

Table VI. Regression of changes in the discount on illiquidity proxies

Coefficient	$S_k \cdot V_k$	Small	Discount	Maturity	Turnover	Credit	Futures	All
$\beta_1 : S_k \cdot V_k$	0.0014	0.0014	0.0014	0.0014	0.0013	0.0014	0.0013	0.0013
	(28.3)	(28.6)	(28.7)	(28.1)	(28.5)	(28.5)	(28.2)	(28.9)
$\beta_2 : S_{k-1} \cdot V_{k-1}$	−0.0014	−0.0014	−0.0014	−0.0014	−0.0013	−0.0014	−0.0041	−0.0013
	(−28.3)	(−28.6)	(−28.7)	(−28.1)	(−28.4)	(−28.5)	(−28.6)	(−28.8)
$\delta_1 : Small_k$		0.1321						0.1021
		(2.9)						(2.4)
$\delta_2 : Discount_k$			0.1586					0.2212
			(2.5)					(2.5)
$\delta_3 : Maturity_k$				0.0818				0.0609
				(2.4)				(2.1)
$\delta_4 : Turnover_k$					0.0025			0.0029
					(1.4)			(1.6)
$\delta_5 : Credit_k$						0.0141		0.0151
						(4.1)		(4.2)
$\delta_7 : Futures_k$							0.0711	0.0647
							(1.9)	(1.7)
$\gamma_0 : Intercept$	−0.0084	−0.0084	−0.0083	−0.0084	0.0078	−0.0083	−0.0075	0.0076
	(−60.1)	(−59.1)	(−58.5)	(−59.8)	(58.7)	(−58.5)	(−58.9)	(56.2)
$\gamma_1 : \Delta t_k$	0.2187	0.2213	0.2226	0.2183	0.2375	0.2216	0.2227	0.2442
	(45.8)	(45.6)	(46.3)	(45.6)	(48.8)	(45.7)	(46.3)	(49.0)
Adjusted R^2	24.88%	25.11%	25.63%	25.98%	25.93%	25.55%	25.43%	27.31%

The table above shows the results of regression (6) that employs the natural logarithm of volume (V_k) interacted with a bid-ask dummy variable (S_k) and adds further macro factors as explanatory variables that have been found to be related to the liquidity return premium. These variables are the small-cap premium ($Small_k$), the closed-end fund discount ($Discount_k$), the bond maturity premium ($Maturity_k$), the market volume ($Turnover_k$), the credit spread over Treasuries ($Credit_k$), and changes in the futures basis ($Futures_k$). Regressions are carried out on a weekly basis with individual macro factors and all factors combined. ELBs are pooled in a random effects, panel data model where the last transaction of each week is used to compute ELB discounts. The t-values are shown in parentheses.

flows from ELBs track the underlying index precisely, while ELBs have discounts that vary substantially and comove over time, this indicates that illiquidity risk may have a systematic component.

We focus on the market-wide component of variations in liquidity that affects financial assets by relating the variability of the discounts over time to macroeconomic variables that have previously been shown to be related to illiquidity. We show that the ex ante illiquidity premium is related to such proxies as the small-firm premium, closed-end fund discount, bond maturity premium, trading volume, credit spreads, and the futures basis.

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