Is Liquidity Risk Priced in Artificial Intelligence ETFs?

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Abstract

We examine if liquidity risk is priced in ETF equity returns and ETF equity premiums. We also show if these relationships hold in the extreme market situations, which includes pre- and post-Covid periods. We find that liquidity risk is an important determinant of ETF equity valuation and equity premiums are sensitive to liquidity levels. The equity premium tends to increase at the higher levels of bid-ask spread in the pre and post-Covid periods indicating that the information is not fully available to public or the investors. Our results are robust across different sub-groups categorised based on the characteristics (age and size) of the ETFs. Our results have implications for asset pricing and price discovery and show that investors hold ETFs with high equity premium even when the liquidity risk is high. A positive liquidity premium exists in Artificial Intelligence ETF markets and has implications for price discovery.

Keywords: Liquidity Risk, ETFs, Artificial Intelligence, AI

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1. Introduction

Artificial intelligence, digital currencies, mobile payments and e-commerce are the results of successful financial innovations and the rapid development of financial technology (Fintech). These are central to investment firms and funding institutions in dealing with risk management associated with crowdfunding. Exchange traded funds (ETFs) offer the option of diversification within the fintech revolution and have developed into an investment vehicle of choice for investors seeking rapid low-cost exposure to broad equity market indices (Lee et.al., 2014). Artificial intelligence ETFs are one category of ETFs appropriate for further anlysis given they provide exposure to companies involved in the development of robots or artificial intelligence, technological improvements in scientific research related to artificial intelligence. These funds are supporting initiatives pushing the technological frontiers and changing the landscape of the economies. AI is a major transforming technology influencing every sector of life and it is a crucial enabler and lever for digital transformation. (Naseeb, 2020).

The volume of ETFs is trending upwards globally. They have been playing an integral role in asset management ever since they were launched in the 1990s. ETFs have grown in size, diversity, scope, complexity and market significance in recent years. The market share of ETFs has risen accordingly and represent, on average, more than 30% of the daily trading volume in US stock markets. The growth of ETFs has been accompanied by an expansion in the range of underlying assets tracked by ETFs (Pagano *et, al,* 2019). Liquidity is an important determinant of stock returns and prior literature provide empirical evidence of this association. Chordia 2009, Liu 2006 among various others have used liquidity measures developed for stocks (Marshall *et al*, 2018).

However, relatively little is known about the relationship between ETFs, equity returns and liquidity risk. Further, the risk-return attributes for ETFs could be more complex than expected. ETFs are hybrid investment vehicles that invest in a basket of securities and issue shares, representing claims to the underlying net asset value (NAV) of the fund, that trade on stock exchanges similar to common stocks (Piccotti, 2018) and affected by two prices (The ETF's tracking index and the underlying security index). This co-movement of asset prices can cause systemic stability issues that has negative consequences on the behaviours of the investors as they are likely to incur losses. ETFs employ committed arbitrageurs, known as Authorized Participants (APs) for trading purposes.

By applying financial engineering techniques, these APs minimize the price differences between the ETFs and the underlying securities. Further, these financial innovations allow the ETFs to offer investors access to stocks at relatively lower cost and offer reduced exposure to a passive investment in a portfolio of stocks. They attract more buying and selling orders and transform illiquid markets into tradable (liquid) markets (Bhattacharya and Hara, 20018). Prior evidence suggests that ETFs are associated with greater co-movement of asset prices. Stocks tend to co-move more with their respective indices once added in ETF portfolios. While in recent crises, ETFs have been sown to play an increasing role in providing secondary market liquidity. Thus, in this paper we examine if ETF returns are sensitive to liquidity risk.

Therefore, in this study we examine the effects of liquidity risk on ETF equity returns. We also show if these relationships hold in extreme market situations, which includes pre and post-Covid crisis periods. We use an index and Artificial Intelligence ETFs listed on the U.S. exchanges for a period 01/072019 to 17/09/2020. All days with no trading volume data are excluded from our research samples. By using range of liquidity and liquidity risk measures, we pursue the following research question: Are ETF equity returns and equity premium sensitive to liquidity risk?

We contribute to the literature by empirically examining whether liquidity risk is priced in Artificial Intelligence ETFs. We use six proxies to show the effects of liquidity risk on the ETF equity returns and ETF premium. We utilise three portfolios of low, medium, and high based on the liquidity risk. Our findings are: (1) investors are inclined to hold ETFs with a high equity premium even when the liquidity risk is high. (2) the effects of bid-ask-spread on the ETFs equity premium are positive and statistically significant. (3) the higher bid ask spread in the post-Covid period suggests a reduction in equity liquidity and aligns with prior literature (Chiu & Tsai, 2017). (4) the equity premium tends to increase at the higher levels of bid-ask spread in both pre and post-Covid periods. This has implications for asset pricing and price discovery. (5) the Amihud illiquidity measure has positive effects on the ETFs equity premium suggesting that liquidity risk is priced and the markets are normal even in extreme market situations. They do not show any signs of price discovery failure, which is an advantage of greater co-movement of asset prices. (6) we also show that ETFs age and size can be an important consideration in explaining the ETF equity returns and liquidity risk and (7) finally, that liquidity risk is an important determinant of ETF equity valuation and equity premiums are sensitive to liquidity levels.

The remainder of this paper is organized as follows: Section 2 presents a review of relevant literature. Section 3 includes the data, methods and description of the liquidity measures and proxies. In Section 4, we present empirical findings. Section 5 provides a discussion and implications of the study and finally, Section 6 concludes.

2. Review of Literature

Prior literature shows a positive relationship between asset pricing and market microstructure (Amihud & Mandelson, 1986) and indicate that systematic liquidity is priced in asset returns (Chordia *et al*, 2001; Acharya & Pedersen, 2005; Liu, 2006). In a liquid market, participants do not suffer large transactions costs and price concessions (Díaz and Escribano,2020), as the gap between the bid-ask prices tends to be narrowed down and depends on how liquid each of the assets traded and on the degree of substitutability among them (see, e.g., Sarr and Lybek, 2002). These microstructure changes in liquidity, volume of trade, and trading costs determine the behaviour of the investors. From the context of ETF liquidity benefits (Barnhart & Rosenstein, 2010 and Agapova, 2011), evidence (Piccotti, 2018) suggests that rational investors should be willing to pay a premium to net asset value (NAV) as long as the cost of the premium is less than the liquidity benefits received.

Alternatively, a rational investor would expect higher returns for stocks with larger bid ask spreads. The empirical evidence on the effects of ETFs liquidity shows that the effects of decay in liquidity (proxied by bid-ask spread) results in price discovery failures (Borkovec & Yegerman, 2010). Literature also provides insights on the positive linkages between increased volatility and higher ownership on the underlying securities of ETFs portfolio and risk premium (Ben-David *et al*, 2018) and also indicates that the liquidity of individual stocks in the underlying portfolio of an ETFs is an important determinant of the tracking errors (Biktimirov *et al*, 2016).

Subsequently, liquidity suppliers can instead become short-term liquidity demanders, rushing to liquidate their positions following negative shocks and thereby causing equity illiquidity and further price declines (Brunnermeier & Pedersen, 2009; Chiu *et al.,* 2012). These behaviours, in extreme situations, could cause the liquidity to disappear - a situation termed a "liquidity black hole" Persaud (2003). Theory suggests capital withdrawals by professional investors in uncertain periods as flight to liquidity (refer Vayanos, 2004). While the experiences of stock market investors during the period surrounding the GFC of 2007-12, shows that investment returns across most asset classes have been highly volatile. Such volatility creates serious financial constraints and investor normally prefer stable returns with a higher degree of certainty as to both income and capital security (Chapman, Ken, 2013). The growing availability of ETFs can affect investors' behaviour, by allowing them to pursue new strategies to seek return, manage risk and access new asset classes. Such changes in investors' behaviour may in turn affect the functioning of financial markets, particularly in times of market stress (Pagano *et al*., 2019).

3. Data and Liquidity variables

The ETF equity daily data is sourced from DataStream. The daily data include bid price, ask price, daily closing price, net asset value (NAV), volume weighted average price, turnover by volume and value and dividend yield. Our sample includes forty Artificial Intelligence-ETFs traded on the NYSE, Dow Jones from 1st January 2015 to 8th October 2020 providing a sample of 13,653 trading days.

Liquidity Measures

Following the literature (Chordia *et al*, 2000), we define the liquidity variables as shown in Table 1 below. P denotes price, subscripts indicate: t = actual transaction, A = ask, B = bid, M = bid-ask midpoint. The bid-ask spread (BAS_t) is derived following the literature (Amihud and Mendelson, 1986; Leirvik *et al*., 2017).

Table 1: Definitions of Liquidity Variables

Liquidity measure	Acronym	Definition	Eq.No
Quoted spread	QSPR	$P_A - P_B$	(1)
Proportional quoted spread	PQSPR	$(P_A - P_B)/P_M$	(2)
Bid-Ask Spread	BAS_t	$BAS_t = [(ASK_t - Bid_t)/(ASK_t)]$	(3)
Effective spread	ES	$2\|P_t - P_M\|$	(4)

Further, by following Pástor and Stambaugh (2003) we measure liquidity as the degree of return reversals following order flow. They propose that less liquid stocks show larger return reversals since orders push the price further away from its fundamental value. We thus, expect, y in Eq. (1) to be negative and larger in absolute magnitude when liquidity is lower:

$$r_{t+1}^{e} = \theta + \varphi r_t + \gamma sign(r_t^e) Dvol_t + \varepsilon_t \qquad (5)$$

where r_t^e is the daily ETFs excess return relative to the NAV on day t; r_t is the daily ETF equity return; $r_{i,d,t}^{e} = r_{i,d,t} - r_{m,d,p}$ and (r_t^e) is one if r_t^e is positive, and −1 otherwise; and DVolt is the dollar volume (in millions of dollars) traded on day t. Eq. (1) is estimated for each ETF equity stock in a month to obtain the monthly liquidity measure. Although gamma, γ, is an imprecise estimate of individual ETFs' liquidity its average across all ETFs in the market is a good estimate of market-wide liquidity level (Pástor and Stambaugh, 2003). Since our analyses are based on portfolio formation, we follow Lam and Tam (2011), and Spiegel and Wang (2005) to use gamma as another liquidity proxy in this paper. In addition to these above liquidity measures, we also use monthly turnover (STURN), measured as the ratio of the monthly trading volume to the number of shares outstanding, and monthly dollar volume as liquidity proxies (DVOL). These liquidity proxies are frequently used in the literature (e.g., Chordia *et al*., 2001; Datar *et al*., 1998; Korajczyk and Sadka, 2008).

Further, we obtain the Amihud illiquidity proxy measures the price changes per unit of dollar volume traded on day *t*.

$$ILLIQ_t = |r_t| / DVol_t, \qquad (6)$$

where r_t is the return on day t and $DVol_t$ is the dollar volume traded on day t. This ratio can only be calculated on days with positive volume.

Following Pagano et., al (2020), we classify the Covid crisis period as fever period (Ramelli and Wagner (2020) from 24th February to 20 March 2020; The restrictive phase[6] of the Covid crisis period being 21 March until 10th May 2020 and followed by the social distancing phase (11th May to 11 August 2020) where businesses and individuals are learning how to live with Covid crisis while maintaining social distancing.

Liquidity Risk Measures

a. *Liquidity Adjusted Capital Asset Pricing Model (LCAPM)*

[6] https://covid19.govt.nz/alert-system/alert-system-overview/

Following the literature (Acharya & Pederson, 2005; Han, & Jian, 2011; Bae, & Daejin, 2020), we use the Liquidity-Adjusted CAPM framework for analysing the pricing of liquidity frictions on ETF equity stocks. This model complements the main framework of the CAPM with constant trading frictions as liquidity is included as an additional element and as implications to the excess returns and market premium. The pricing formula is shown below:

$$E(R_{t-}^{j}\ R_f) = E(C_t^j + \gamma\beta_{net}^j) \qquad (8)$$

Where

$$\gamma = E(R_t^M - C_t^M - R_f) \qquad (9)$$

$$\beta_{net}^j = \frac{cov(R_t^j - C_t^j,\ R_t^M - C_t^M)}{VAR(R_t^M - C_t^M)} \qquad (10)$$

We construct a normalised joint illiquidity cost measured by combining transaction costs and selling cost together. Effective spread is used as a proxy for the transaction cost and Amihud Illiquidity is used as a proxy for selling cost. Following Acharya and Pedersen (2005), the transaction cost and selling cost are combined and the normalised illiquidity cost of individual ETF equity j on day t denoted by C_t^j, is then estimated by combining effective spread and illiquidity cost as shown below:

$$C_t^j = aILLIQ_t^j P_t^M + b \qquad (11)$$

Where P_t^M is the ratio of the market return of the price index on which the ETFs are traded and the one at the start day of our data range, so as to include inflation. The coefficients a and b are selected to ensures that the cross-sectional distribution of illiquidity cost C_t^j, has the same mean and variance as Effective $Spread_t^j$.

b. Liquidity Risk – Daily ETF Equity Returns Reversals

Following Lou & Sadka (2011), we calculate the liquidity exposure of a given ETF equity by regressing the daily value weighted ETF returns on the market index returns. We consider the coefficient of the liquidity factor β_i^{Liq}, as a proxy for aggregate liquidity risk (beta) obtained. It measures the sensitivity of the ETF equity to changes in the market wide liquidity. It is calculated as shown below:

$$R_{i,t} - R_{f,t} = \propto_i + \beta_i^{Ret}\left(R_{m,t} - R_{f,t}\right) + \beta_i^{Liq} L_{m,t} + \varepsilon_{i,t} \qquad (8)$$

Where:

$R_{i,t}$ = the ETF equity return i during month t

$R_{f,t}$ = the monthly risk-free rate

$R_{m,t}$ = the value weighted market average return

$L_{m,t}$ = a liquidity risk factor and

$\varepsilon_{i,t}$ = an error term

We use the Pástor and Stanbaugh (2003) model that is based on daily ETF equity price reversal, for the estimation of liquidity beta.

4. Empirical Analysis:

The descriptive statistics in the Table 2 represents summary statistics of explanatory variables used throughout the study. It is evident that the means and median of the ES, BAS, volume in dollars, Amihud Illiquidity and market value are higher under Panel C when compared to the two panels A and B. This suggests that there is a drop in the liquidity in the post-Covid period. Further, the high volume in dollars in the post-Covid period suggests that it has been easier for traders to buy and/or sell in large dollar amounts without moving the price substantively and has the potential to transform the illiquid market to a tradable market. Therefore, the ETF returns are relatively low in the Panel C. However, with the exception of equity return, the maximum values of all variables under the panel C are lower than those of Panels A and B.

Table 3 presents correlation analysis among explanatory variables. No significantly high correlation (>0.6) is identified with the exception of the ETF age and volume in dollar. The effective spread, bid-ask-spread, volume in dollar, ETF age, CAPM-Beta, FSR are positively correlated to the ETF equity returns.

Table 2. Descriptive statistics time-series means

Variable	Observations	Mean	Median	S.D.	Min	Max
Panel A: Full Sample Period						
ETFs Equity Returns	13653	0.0169	0.0071	0.0268	-0.0252	0.1785
ETFs Premium	13652	0.0168	0.0060	0.1215	-2.3033	3.3813
ES	13653	0.0061	0.0005	0.0331	0.0000	1.2027
BAS	13653	0.0024	0.0016	0.0066	0.0000	0.4714
Volume in Dollar	13653	64.01	30.43	71.01	9.70	336.73
Amihud Illiquidity	13653	0.0006	0.0003	0.0006	0.0000	0.0037
ETF Age	12987	5.5839	2.0301	6.3531	0.7644	21.2055
TESD	13653	1.3294	0.4630	5.4476	0.0427	35.7580
CAPM - Beta	13653	-0.0043	-0.0012	0.0101	-0.0787	0.0000
FSR	13612	0.0169	0.0171	0.0007	0.0157	0.0182
Market Value	13631	4349	36	15891	0.9600	144492
Panel B: pre-Covid Crisis Period						
ETFs Equity Returns	6847	0.0173	0.0063	0.0297	-0.0241	0.1785
ETFs Premium	6846	0.0177	0.0054	0.1245	-2.3033	3.3813
ES	6847	0.0054	0.0004	0.0291	0.0000	0.3854
BAS	6847	0.0020	0.0015	0.0035	0.0000	0.2307
Volume in Dollar	6847	60.20	29.52	64.20	10.58	336.73
Amihud Illiquidity	6847	0.0002	0.0002	0.0002	0.0000	0.0013
ETF Age	6513	5.5839	2.0301	6.3533	0.7644	21.2055
TESD	6847	1.3294	0.4630	5.4478	0.0427	35.7580
CAPM - Beta	6847	-0.0065	-0.0037	0.0105	-0.0641	0.0000

FSR	6806	0.0174	0.0174	0.0004	0.0159	0.0182
Market Value	6825	3797	23	13460	0.9600	144492
Panel C: post-Covid Period						
ETFs Equity Returns	5248	0.0146	0.0073	0.0219	-0.0252	0.1053
ETFs Premium	5248	0.0136	0.0051	0.1150	-2.2828	2.0198
ES	5248	0.0070	0.0006	0.0360	0.0000	0.4892
BAS	5248	0.0030	0.0017	0.0097	0.0000	0.4714
Volume in Dollar	5248	66.82	31.04	75.99	9.70	328.70
Amihud Illiquidity	5248	0.0008	0.0008	0.0005	0.0001	0.0031
ETF Age	4992	5.5839	2.0301	6.3535	0.7644	21.2055
TESD	5248	1.3294	0.4630	5.4479	0.0427	35.7580
CAPM - Beta	5248	-0.0027	-0.0003	0.0105	-0.0787	0.0000
FSR	5248	0.0164	0.0161	0.0004	0.0157	0.0174
Market Value	5248	4838	40	17759	1.4600	140024

Notes: This table gives an overview of the variables for daily ETF equity data used in the study. It presents a descriptive statistic for the sample period that ranges from 1/07/2019 to 08/10/2020 and covers the period of before the Covid outbreak and after the outbreak.

Table 3. Correlation Matrix of the variables used in the study

S.No	Variables	1	2	3	4	5	6	7	8	9	10
1	ETFs Equity Returns	1.000									
2	ETFs Equity Premium	0.241***	1.000								
3	ES	(0.077)***	-0.012	1.000							
4	BAS	0.017**	0.0367*	0.0688*	1.000						
5	Volume in Dollar	0.019**	-0.0380*	-0.001	-0.1247*	1.000					
6	Amihud Illiquidity	-0.017	-0.013	-0.020	0.0653*	-0.3517*	1.000				
7	ETF Age	0.022	-0.006	0.0443*	-0.1564*	0.8732*	-0.3893*	1.000			
8	TESD	-0.003	-0.007	0.014	0.1235*	0.1073*	0.0612*	-0.0959*	1.000		
9	LR-Beta	-0.009	0.008	-0.004	0.0770*	-0.4567*	0.0284*	-0.4449*	0.2743*	1.000	
10	CAPM - Beta	0.0250*	0.007	0.014	0.018	0.014	0.1597*	0.000	0.000	0.000	1.000
11	FSR	0.0252*	0.1094*	-0.0562*	-0.0246*	-0.0889*	-0.5581*	-0.001	0.003	0.003	-0.1972*

ETF equity turnover by volume is plotted in Figure 1a for the pre-Covid period and in Figure 1b for the post-Covid. Turnover by volume in Figure 1b is more volatile, with the maximum volume trade reaching 5,000 and mostly traded above 1,000.

Figure 1a: ETFs Equity Turnover by Volume - pre Covid-Period

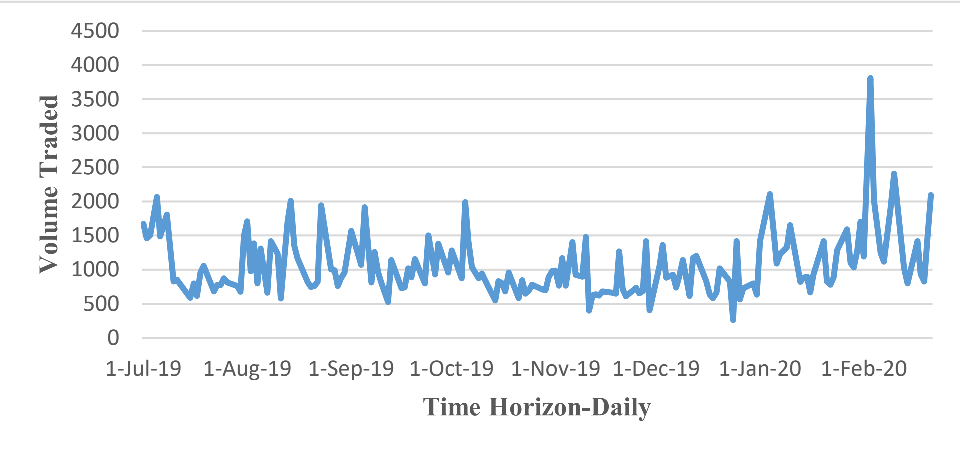

Figure 1b: ETFs Equity Turnover by Volume – post-Covid Period

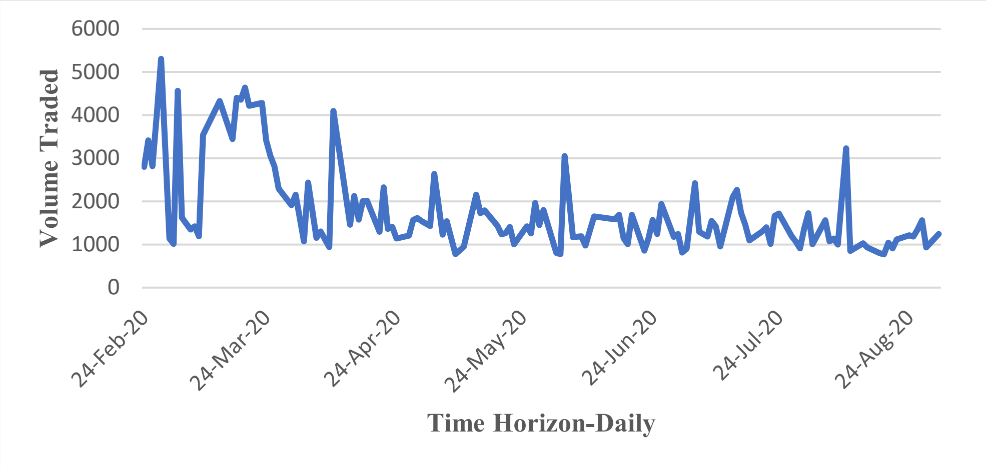

Table 4 presents the results of ETF equity performance sorted by liquidity. We perform two tests to determine whether the ETF value weighted portfolio returns means are the same or differ across the three levels of liquidity, grouped as low, medium and high. The first test is the one-way analysis of variance (ANOVA) and the second is the Kruskal-Wallis equality-of-populations rank test (KWR Test).

The results are presented in the two main panels A and B. Panel A presents the ETF value weighted equity returns performance and the Panel B present ETF equity premium, expressed as a difference between ETFs value weighted portfolio return and net asset value (NAV) of the underlying security. The two main panels are further grouped into two sub-panels each (Panels A1 & A2 and Panels B1 & B2) to show the performance in the pre-Covid period and the post-Covid period. The results from the panels shows that an equity premium exists at higher levels of BAS across three panels and the Panel B, B1 and B2 at 1% and 5% levels of significance. The results are similar in the pre and post-Covid periods. Similar results are evident for all the other liquidity variables. The equity premium is statistically significant at 1% level for ES and Amihud for the overall period (panel B) and post-Covid period (panel B2).

Table 4: Portfolio performance sorted by Liquidity

Details	**ES**	**BAS**	**STURN**	**Amihud**
Panel A: ETF Equity Returns				
Low	0.017	0.017	0.017	0.02
Medium	0.018	0.017	0.016	0.014
High	0.016	0.016	0.018	0.016
F-Test	6.42***	0.87	6.03***	53.77***
KWR Test	0.0001***	0.0211**	0.0001***	0.0001***
Panel B: ETF Equity Premiums				
Low	0.013	0.011	0.018	0.022
Medium	0.012	0.014	0.016	0.014
High	0.026	0.025	0.016	0.015

F-Test	17.95***	16.56***	0.27	5.36***
KWR Test	0.0001***	0.0620*	0.103	0.0023***
Panel A1: ETF Equity Returns pre-Covid				
Low	0.017	0.017	0.017	0.021
Medium	0.019	0.018	0.016	0.013
High	0.015	0.017	0.018	0.014
F-Test	11.09***	1.02	2.95*	55.12***
KWR Test	0.0001***	0.0081***	0.0001***	0.0001***
Panel B1: ETF Equity Premiums pre-Covid				
Low	0.017	0.013	0.02	0.023
Medium	0.019	0.017	0.016	0.012
High	0.018	0.024	0.016	0.011
F-Test	0.23	4.16**	0.94	6.53***
KWR Test	0.0716*	0.0001***	0.238	0.0001***
Panel A.2: ETF Equity Returns post-Covid				
Low	0.015	0.015	0.013	0.02
Medium	0.013	0.013	0.015	0.014
High	0.015	0.015	0.016	0.016
F-Test	4.47**	3.43**	7.50***	53.77***
KWR Test	0.359	0.0396**	0.0001***	0.564
Panel B.2: ETF Equity Premiums post-Covid				
Low	0.004	0.005	0.012	0.022
Medium	0.003	0.008	0.014	0.014
High	0.029	0.025	0.014	0.015
F-Test	29.91***	16.56***	0.1	5.36***
KWR Test	0.0001***	0.0001***	0.51	0.0048***

Notes: This table reports results for ETF equity data used in the study over the sample period that ranges from 1/07/2019 to 08/10/2020. At the beginning of each month stocks are sorted in ascending order based on their liquidity measures. Stocks are then grouped into three portfolios of low, medium, and high liquidity. The time series averages of these ETFs portfolio value weighted returns are reported here. The ETF Equity Premium is difference between the portfolio value weighted price and NAV. The variable *ES is* the monthly average of two times the absolute value of the log of the price minus log of the mid-spread; *BAS* is the monthly average of the proportional bid–ask spread divided by ask price; *Amihud* is defined as the average of the monthly ratio of the absolute return to the dollar trading volume Amihud (2002); *STURN* is the ratio of the monthly trading volume to the number of shares outstanding. *** Indicates 1% significance level, ** Indicates 5% significance level and * Indicates 10% significance level.

We arrange portfolios based on historical exposure to liquidity risk as this method is considered a plausible approach for observing the hedging properties of these portfolios in times of unexpected drops in liquidity levels. We therefore, arrange ETF equity returns based on five liquidity factors to measure liquidity risk as shown in the Table 4. We also present the difference between the ETF Portfolio value weighted price and NAV as the ETF equity premium.

It is evident from Table 5 that the results regarding ETF returns are mixed. Panel A indicates higher ETF equity returns occur at medium and higher levels of liquidity risks in the cases of LR-Beta and LR-FSR, and at 1% level according to F-Test and KWR test and LR-MV. In contrast, in the case of LR-CAPM, LR-TESD and LR-PS, the ETF equity returns are higher at medium and lower levels of liquidity risk (results not significant as per F-Test).

The estimated ETF equity premiums in the Panel B suggest higher premiums at the higher (or medium levels) levels of liquidity risk across all the panels with the exception of the LR-PS model. It is also noteworthy that the equity premiums shown in the Panel B are higher than the ETF-Equity returns shown in the Panel A at higher levels of the liquidity risk with the exception of LR-PS model. This suggests that equity premiums of ETFs with higher liquidity risk are more sensitive to underlying asset values and the market index.

Table 5: Portfolio performance sorted by liquidity risk

Details	LR-Beta	LR-CAPM	LR-MV	LR-FSR	LR-TESD	LR-PS
Panel A: ETF Equity Returns at different levels of Liquidity Risk						
Low	0.0148	0.0172	0.0167	0.0182	0.0170	0.0197
Medium	0.0195	0.0170	0.0163	0.0117	0.0170	0.0273
High	0.0164	0.0163	0.0175	0.0208	0.0166	0.0036
F-Test	36.71***	1.3100	2.1200	141.20***	0.3400	1077.66***
KW-RankTest	0.0001***	0.0512*	0.3580	0.0001***	0.3580	0.0001***
Panel B: ETF Equity Premiums at different levels of Liquidity Risk						
Low	0.0182	0.0153	0.0124	-0.0112	0.0168	0.0233
Medium	0.0125	0.0179	0.0194	0.0368	0.0173	0.0362
High	0.0197	0.0172	0.0182	0.0250	0.0163	-0.0090
F-Test	4.46**	0.5700	4.57**	197.53***	0.0900	171.21***
KW-RankTest	0.0001***	0.0035***	0.0685*	0.0001***	0.0001***	0.0001***

Notes: This table reports results for ETF equity data of businesses involved in advanced technology (Artificial intelligence) used in the study over the sample period that ranges from 1/07/2019 to 08/10/2020. At the beginning of each month, stocks are sorted in ascending order based on their liquidity risk measures. ETF Stocks are then grouped into three portfolios of low, medium, and high liquidity betas/liquidity risk. The value-weighted monthly portfolio returns are calculated for each portfolio. Panel A reports the portfolio's value weighted returns. Panel B reports the equity premium returns averages of the high–low portfolios for three portfolios of low, medium, and high liquidity betas/liquidity risk.
*** Indicates 1% significance level, ** Indicates 5% significance level and * Indicates 10% significance level.

The results for the full sample period are presented in the Table 6. It is evident from Table 6 that the ETF equity returns reported in Panel A, are high at the higher levels of liquidity risk gauged by systematic risk (Beta) at 1% level according to F-Test and KWR test and by market value at 5% level as per KWR test in the pre-Covid period. However, the ETF equity returns from the Panel B, are low at the higher levels of liquidity risk gauged by systematic risk (Beta) at 1% level according to F-Test and KWR test and by market value at 10% level as per F-test, LR-CAPM at 5% and 1% levels according to F-Test and KWR test and in the post-Covid period.

The ETF equity returns are identical at the lower and higher levels of liquidity risk measured by firm specific risk (FSR) at 1% level according to F-Test and KWR test, capital adjusted pricing model (CAPM) and tracking error standard deviation (TESD), indicating no-arbitrage state of condition and price sensitivity is zero in the pre-Covid period.

The estimates of ETF equity premiums in Panel A1 in the pre-Covid period, of Table 6 show that ETF equity premiums are high at the higher (or medium levels) levels of liquidity risk across all the panels with the exception of LR-PS model generally, at 1% level according to F-Test and KWR test. In contrast, in the post-Covid period, the results reported in panel B1 are mixed. The ETF equity premium is high at the higher levels of liquidity risk gauged by systematic risk at 1% level according to KWR test and by market value and FSR at 1% level as per F-Test and KWR test and show contrast results under LR-PS in the post-Covid period. This indicates that liquidity risk is priced by equity premium in the pre- and post-Covid periods.

Table 6: Sub-sample analysis of ETFs during the Covid crisis sorted by liquidity risk

Details	LR-Beta	LR-CAPM	LR-MV	LR-FSR	LR-TESD	LR-PS
Panel A: ETF Equity Returns in Pre-Covid Period						
Low	0.015	0.017	0.014	0.023	0.017	0.019
Medium	0.019	0.018	0.017	0.008	0.018	0.037
High	0.026	0.017	0.018	0.021	0.017	0.002
F-Test	57.53***	0.310	1.910	138.41***	0.420	955.09***
KWR Test	0.0001***	0.737	0.0467**	0.0001***	0.388	0.0001***
Panel A1: ETF Equity Premiums in Pre-Covid Period						
Low	0.019	0.014	0.007	-0.062	0.017	0.023
Medium	0.007	0.020	0.017	0.016	0.019	0.047
High	0.034	0.018	0.018	0.025	0.017	-0.008
F-Test	15.47**	1.290	0.620	79.39***	0.190	112.42***
KWR Test	0.0001***	0.0260**	0.727	0.0001***	0.406	0.0001***
Panel B: ETF Equity Returns in post-Covid Period						
Low	0.016	0.016	0.014	0.015	0.015	0.018
Medium	0.017	0.014	0.015	0.015	0.015	0.020
High	0.012	0.014	0.012	-0.001	0.015	0.005
F-Test	28.88 ***	3.04**	2.50*	3.71**	0.020	264.73***
KWR Test	0.0001***	0.0096***	0.161	0.0001***	0.613	0.0001***
Panel B1: ETF Equity Premium in post-Covid Period						
Low	0.013	0.014	0.009	-0.003	0.014	0.022
Medium	0.013	0.013	0.018	0.036	0.013	0.027
High	0.014	0.014	0.049	0.107	0.013	-0.010
F-Test	0.080	0.020	11.05 ***	80.36 ***	0.040	54.52 ***
KWR Test	0.0001***	0.0145**	0.0001***	0.0001***	0.108	0.0001***

Notes: This table reports results for ETF equity data of businesses involved in advanced technology (Artificial intelligence) used in the study over the sample period that ranges from 1/07/2019 to 08/10/2020. At the beginning of each month stocks are sorted in ascending order based on their liquidity risk measures. ETF Stocks are then grouped into three portfolios of low, medium, and high liquidity betas/liquidity risk. The value-weighted monthly portfolio returns are calculated for each portfolio and presented in the Panels A and the ETFs equity premium is presented in A1 in the pre-Covid period. While the Panels B and B1 reports the equity premium returns averages of the high–low portfolios for three portfolios of low, medium, and high liquidity betas/liquidity risk in the post-Covid period.

*** Indicates 1% significance level, ** Indicates 5% significance level and * Indicates 10% significance level.

Robustness Checks

We also show in Table 7, 8, 9 and 10 the relationship between ETF equity returns and liquidity risk by using two other dimensions of liquidity i.e., age and size (Houweling *et al*., 2005; Longstaff *et al*. 2005; Ericsson and Renault, 2006, and Bao and Pan, 2013 among few others). While Table 7 presents the results adjusted to above average size, proxied by market capitalization in the pre-Covid period, Tables 8 presents the results adjusted to the above average size, in the post-Covid period.

We consider age in its absolute term, i.e., expressed as years since issuance and then sub-divide the ETFs into two categories as above and below two years. In Table 6 the results presented for age and size based on market capitalization, are likely to affect the tradability of the ETFs. Not all financial assets can be traded easily and quickly without losing money value or without incurring higher transaction costs. It is evident from Table 6 that the ETF returns and ETF premium are largely high at the medium and higher levels of liquidity risk across all of the measures, with the exception of LR-PS. This indicates that there is no significant difference in ETF performance even after arranging them based on size and age for different liquidity risks. This finding suggests that some large size ETFs although liquid, involve significant liquidity risk and that some less liquid underlying securities have a high liquidity risk exposure.

The results presented in Table 7 suggest that the relationship between ETF equity returns and liquidity risk are statistically significant at the higher levels of liquidity risk when measured by liquidity risk-beta, LR-market value and LR-FSR. While the results from LR-PS indicate the equity returns and equity premium are high at the medium level for seasoned ETFs with age above 2 years and size above average. While the results of Panels B and B1 for the ETFs below 2 years age and above average size show mixed results. The equity returns are higher at lower levels of liquidity risk as per LR-CAPM, LR-MV and LR-PS, while higher levels of risk as per LR-Beta. However, the results from the panel B1 are in contrast to the results presented in the panel B. We show that liquidity categorisation might explain the possibility of ETFs to trade at a premium to the underlying net asset value (NAV) and significance of the age and size in premiums.

Table 7. Sub-sample analysis of ETFs based on size, age sorted by liquidity risk in the pre-Covid Period (Size above average)

Details	LR-Beta	LR-CAPM	LR-MV	LR-FSR	LR-TESD	LR-PS
Panel A: Equity returns of EFTs > 2 years of Age and Size above Average						
Low	0.014	0.018	0.080	0.025	0.019	0.019
Medium	0.020	0.017	0.017	0.008	0.018	0.036
High	0.027	0.018	0.019	0.021	0.017	0.002
F-Test	31.32 ***	0.260	6.67***	60.50 ***	0.380	396.65 ***
KWR Test	0.0001***	0.385	0.00121**	0.0001***	0.505	0.0001***
Panel A1: Equity Premium of EFTs > 2 years of Age and Size above Average						
Low	0.015	0.014	-0.107	-0.067	0.013	0.023
Medium	0.008	0.014	0.017	0.018	0.017	0.034
High	0.030	0.018	0.013	0.020	0.012	-0.007
F-Test	6.35***	0.200	1.860	56.99***	0.690	45.30***
KWR Test	0.0001***	0.319	0.0904*	0.0001***	0.575	0.0001***
Panel B: Equity returns of EFTs < 2 years of Age and Size above Average						
Low	0.013	0.032	0.052	0.030	0.001	0.020
Medium	0.020	0.016	0.016	0.008	0.016	0.030
High	0.024	0.016	0.030	0.019	0.017	0.003

F-Test	3.18**	5.92**	4.39**	9.38***	0.110	27.35***
KWR Test	0.313	0.0632*	0.229	0.0012***	0.693	0.0001***
Panel B1: Equity Premium of EFTs < 2 years of Age and Size above Average						
Low	0.016	-0.159	-0.161	-0.115	0.001	0.024
Medium	0.010	0.013	0.010	0.017	0.006	-0.012
High	-0.055	0.013	-0.203	0.018	0.002	-0.006
F-Test	12.77***	73.92***	29.62***	38.89***	0.200	5.05***
KWR Test	0.0040***	0.0002***	0.0969*	0.0001***	0.662	0.0001***

Notes: This table reports results for ETF equity data of businesses involved in advanced technology (Artificial intelligence) used in the study over the sample period that ranges from 1/07/2019 to 08/10/2020. At the beginning of each month stocks are sorted in ascending order based on their liquidity risk measures. ETF Stocks are then grouped into three portfolios of low, medium, and high liquidity betas/liquidity risk. The value-weighted monthly portfolio returns after grouping into above and below two years of age of the ETFs are calculated for each portfolio and presented in the Panels A and the ETFs equity premium is presented in A1 for the ETFs who are above two years of age and the size above average (market capitalisation) in the Pre-Covid period. While the Panels B and B1 reports the equity premium returns averages of the high–low portfolios for three portfolios of low, medium, and high liquidity betas/liquidity risk for the ETFs who are below two years of age and the size below average in the Pre-Covid period.

*** Indicates 1% significance level, ** Indicates 5% significance level and * Indicates 10% significance level.

Table 8 presents the results in the post-Covid period. The relationship between the ETF equity returns and liquidity risk for the ETFs, which are above the average market capitalisation of after adjusting for the ETFs are analysed. The results show equity returns and equity premium are generally higher at the lower levels of liquidity risk for the ETFS above and below two years of age.

Table 8. Sub-sample analysis of ETFs based on size, age sorted by liquidity risk in the post-Covid Period (Size above average)

Details	LR-Beta	B-CAPM	LR-MV	LR-FSR	LR-TESD	LR-PS
Panel A: Equity returns of EFTs > 2 years of Age and Size above Average						
Low	0.014	0.016	0.017	0.015	0.017	0.020
Medium	0.018	0.015	0.017	0.015	0.017	0.020
High	0.013	0.015	0.018	-0.002	0.017	0.006
F-Test	10.77***	0.680	1.120	3.40**	0.360	107.74***
KWR Test	0.0001***	0.419	0.0091***	0.0001***	0.329	0.0001***
Panel A1: Equity Premium of EFTs > 2 years of Age and Size above Average						
Low	0.013	0.012	0.014	-0.005	0.016	0.024
Medium	0.015	0.014	0.017	0.038	0.017	0.022
High	0.010	0.009	0.017	0.099	0.015	-0.011
F-Test	0.620	0.230	0.580	70.55***	0.200	36.26***
KWR Test	0.0001***	0.524	0.0067***	0.0001***	0.460	0.0001***
Panel B: Equity returns of EFTs < 2 years of Age and Size above Average						
Low	0.018	0.015	0.016	0.016	0.015	0.019
Medium	0.017	0.015	0.015	0.014	0.015	0.020
High	0.013	0.015	0.015	0.002	0.015	0.008
F-Test	1.990	0.040	0.680	0.820	0.030	13.25***
KWR Test	0.0722*	0.484	0.257	0.0865*	0.502	0.0001***
Panel B1: Equity Premium of EFTs < 2 years of Age and Size above Average						

Low	0.017	-0.032	-0.025	-0.016	0.001	0.023
Medium	0.011	0.014	0.013	0.032	0.006	-0.014
High	-0.019	0.014	0.013	0.017	-0.011	-0.011
F-Test	3.27**	13.30***	9.22***	6.62***	1.900	3.69**
KWR Test	0.0001***	0.0020***	0.0189***	0.0045***	0.842	0.0001***

Notes: This table reports results for ETF equity data of businesses involved in advanced technology (Artificial intelligence) used in the study over the sample period that ranges from 1/07/2019 to 08/10/2020. At the beginning of each month stocks are sorted in ascending order based on their liquidity risk measures. ETF Stocks are then grouped into three portfolios of low, medium, and high liquidity betas/liquidity risk. The value-weighted monthly portfolio returns after grouping into above and below two years of age of the ETFs are calculated for each portfolio and presented in the Panels A and the ETFs equity premium is presented in A1 for the ETFs who are above two years of age and the size above average (market capitalisation) in the post-Covid period. While the Panels B and B1 reports the equity premium returns averages of the high–low portfolios for three portfolios of low, medium, and high liquidity betas/liquidity risk for the ETFs who are below two years of age and the size below average in the post-Covid period.
∗∗∗ Indicates 1% significance level, ∗∗ Indicates 5% significance level and ∗ Indicates 10% significance level.

Table 9 shows results from OLS and Quantile regression models (Huang *et al*., 2011) on total sample data. Numerous interesting findings emerge. It is evident from the Table 10 that the effects of bid-ask-spread on the ETFs equity premium are positive and statistically significant at 5% level. The positive effects of Amihud Illiquidity on the ETF equity premium at 5% level of significance indicates equity premium is compensating for Liquidity risk. The effective spread is significant statistically at 5% level and inversely related to the ETFs equity returns and ETFs premium. It is effective across all the three quantiles, while the bid-as-spread is more effective as per OLS and for the quantile regression at Q25 and Q50. The results are robust across the two regression approaches. An increase in the CAPM-Beta causes the ETF equity premium to increase significantly at 5% level at the higher levels of quantile regression and aligns with prior research (Lou & Sadka, 2011). The R^2 is relatively high for the regression using ETF equity premium.

Table9. Effects of liquidity risk on ETF equity returns and ETF equity premium

	ETF Equity Returns				**ETF Equity Premium**			
Variables	**Mean**	**Q 25**	**Q 50**	**Q 75**	**Mean**	**Q 25**	**Q 50**	**Q 75**
Effective Spread	-0.065	-0.008	-0.032	-0.082	-0.042	-0.022	<0.001	-0.082
	(9.17)**	(13.19)**	(18.06)**	(10.94)**	-1.5	(7.08)**	(9.92)**	(14.87)**
Bid-Ask-Spread	0.111	0.054	0.104	0.114	0.554	0.23	0.336	1.97
	(3.09)**	1.64	(5.30)**	0.83	(3.92)**	(2.96)**	1.43	(2.00)*
Volume in Dollar value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	0.40	(2.57)*	1.22	0.94	-0.83	(2.78)**	(4.65)**	(3.58)**
Amihud Illiquidity	0.106	0.209	0.954	1.569	7.578	-7.528	3.037	16.048
	0.18	(1.99)*	(2.28)*	1.23	(3.17)**	(7.12)**	(2.60)**	(6.00)**
ETF Age	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	-1.91	(7.10)**	(3.04)**	-1.6	-0.36	(7.30)**	-0.86	(3.44)**
TESD	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001
	-0.74	-0.53	-0.43	-1.19	0.42	(6.27)**	-1.2	(5.22)**
LR-Beta	-0.066	-0.065	-0.033	-0.014	1.973	0.333	0.72	-0.001
	-0.15	-0.73	-0.09	-0.02	-1.15	-0.64	-1.44	<0.001
PS Returns Increase	<0.001	<0.001	<0.001	0.001	-0.006	-0.013	-0.006	-0.005

	(3.91)**	-0.67	(4.19)**	(6.99)**	(33.96)**	(13.04)**	(27.74)**	(17.51)**
CAPM - Beta	0.099	0.004	-0.002	0.133	0.156	-0.046	0.077	0.27
	(4.15)**	(2.18)*	-0.19	(4.18)**	1.65	(3.02)**	(3.57)**	(8.63)**
Firm Specific Risk	1.218	-0.432	-0.543	0.939	14.663	-2.182	2.233	11.421
	(2.61)**	(5.22)**	-1.65	0.98	(7.95)**	(3.43)**	(3.19)**	(6.98)**
Constant	-0.003	0.008	0.015	0.006	0.248	0.032	0.038	0.172
	<0.001	(4.83)**	(2.15)*	-0.37	(7.00)**	(2.49)*	(2.71)**	(4.97)**
Observations	12,948	12,948	12,948	12,948	12,947	12,947	12,947	12,947
Pseudo R-Square	0.01	0.004	0.008	0.0108	0.25	0.2934	0.2238	0.2469

Notes: This table reports the results from the cross-sectional regressions of value-weighted monthly portfolio returns on liquidity risk measures, proxied by liquidity risk adjusted Beta, Beta-CAPM model, PS-Illiquidity shocks and Price reversals (Pástor–Stambaugh factor, 2003), Amihud illiquidity measure, TESD, ES, BAS and Volume turnover.

*** Indicates 1% significance level, ** Indicates 5% significance level and * Indicates 10% significance level.

5. Discussion of the empirical findings

Our study provides insights on liquidity risk and pricing. This is important because liquidity is seen as a significant feature to enable efficient financial markets and a flexible macroeconomy. It is defined as the ease of trading with financial assets. Not all financial assets can trade easily and quickly without losing money value. We examine the effects of liquidity risk on ETF equity premium for the period that covers the pandemic crisis. These AI-ETFs are important because they represents a global market worth billions of dollars. These ETFs invests in companies whose products and services are used across the sectors: automobiles, utilities and infrastructure, consumer staples, health care, industrial and primary and so on. For instance, these AI-ETFs invests in companies that potentially stand to benefit from increased adoption and utilization of robotics and artificial intelligence. The wide range of practical applications includes smartphone face recognition, predictive algorithms in internet search, robotic surgical systems, smart home devices, autonomous vehicles, industrial and robotics products that are used in utilities and infrastructure.

Our results show that the liquidity risk in ETFs equity is priced and investors are willing to pay high price at higher levels of liquidity risk. Further, the co-movement of asset prices in these AI- ETFs are positive and very much incentivising the investors with ETF equity premium aligns prior evidence (Piccotti, 2018), and do not show signs of causing systemic stability issues. This could be because of the e-commerce boom that transformed the consumer landscape to a largely digital economy since the outbreak of the pandemic, where social distance and self-quarantine have become common in every day life. Our findings override the concerns expressed in the prior literature on traditional common stocks, in which the liquidity suppliers turning into short-term liquidity demanders, thereby causing equity illiquidity and further price declines during the market crisis (Brunnermeier & Pedersen, 2009; Chiu *et al.,* 2012) causing "liquidity black hole", by Persaud (2003). These results support the notion that ETF equity can not only be substitutes for mutual funds and pension funds, but also enable investors to earn a return on their investments even during the period of extreme market situations like the Covid19 pandemic. Individual investors may invest in AI-ETFs to hedge portfolios from liquidity risk. AI-ETFs therefore, offer many unique features including several distinct trading advantages and play a role in making the funds available to corporates in both normal periods and extreme market situations.

6. Conclusions

During the recent crisis, ETFs played an increasing role in providing secondary market liquidity. Yet, little focus has been made on ease of trading and returns to ETFs, transaction costs and ETF trading volume. We examine if the ETF equity returns are sensitive to liquidity risk and whether the changes in liquidity levels affect the equity premium. We use six liquidity risk measures that capture all the important dimensions of liquidity risks. The LR-Beta is a liquidity-adjusted beta obtained by the CAPM approach. It factors the liquidity risk and market risk. The second measure of liquidity risk is the systematic risk measure obtained from the CAPM model, this measure is the liquidity risk obtained from market value, the fourth measure is an idiosyncratic risk, the fifth measure is expressed as a deviation of tracking error and NAV and fifth measure captures the sensitivities of price variations on the market returns and volume traded.

We find that liquidity risk is an important determinant of ETFs equity valuation and equity premiums are sensitive to liquidity levels. Our tests confirm that the liquidity risk is priced in ETF equity returns and the equity premium. The equity premium tends to increase at the higher levels of bid-ask spread in the pre and post-Covid period indicates that the information is not fully available to the public or the investors. These findings suggest the possibilities of asset pricing and price discovery. Further the Amihud illiquidity measure shows a positive effect on ETF equity premiums and shows that the liquidity risk is priced in situations where the markets are not only normal but also in crisis times. They do not show any signs of price discovery failures, which is an advantage of greater co-movement of asset prices. We find that the small-sized stocks have high liquidity risk even after adjusting for the age of the ETF supports the prior literature (Acharya and Pedersen, 2005). Our findings also show investors are inclined to hold ETFs with high equity premiums even when the liquidity risk is high (Pástor and Stambaugh, 2003). Our results are robust across the different sub-group types categorised based on the age and size of the ETFs. During the post-Covid period, the ETF equity returns show illiquidity discounts.

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