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MODELING DISTRESS IN US HIGH YIELD MUTUAL FUNDS BEFORE AND DURING THE COVID-19 PANDEMIC

Łukasz Szymczyk, M.Sc.

Department of Investment and Financial Markets, Institute of Finance
Poznan University of Economics and Business
e-mail: lukasz.szymczyk@ue.poznan.pl
ORCID: 0000-0002-9688-5901

Richard Van Horne, Ph.D.

Department of Investment and Financial Markets, Institute of Finance
Poznan University of Economics and Business
e-mail: richard.vanhorne@ue.poznan.pl
ORCID: 0000-0002-4648-9601

Katarzyna Perez, Ph.D., Associate Professor

Department of Investment and Financial Markets, Institute of Finance
Poznan University of Economics and Business
e-mail: katarzyna.perez@ue.poznan.pl
ORCID: 0000-0003-3331-8456

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Abstract

Research background: In March 2020, when the US financial markets were in the grip of the COVID-19 crisis, the Fed instituted various policies and programs to alleviate stress in financial markets. One such program involved the Fed purchase of securities and ETFs in certain market segments, including high yield bonds. This buying action inspired investors to join the Fed (or front-run the Fed) in the high yield bond market, resulting in the tightening of spreads in that market to historically tight levels.
Purpose: In this research we investigate whether investors could have seen any signs of higher liquidity risk in US high yield mutual funds since the beginning of COVID-19 pandemic and avoid it. Theoretically, funds with heightened liquidity risk should have higher historical returns (adjusted for interest rate risk and credit risk) because borne risk requires return as compensation. But because of the unusual market conditions during the COVID-19 pandemic investors could look inside funds (to see what bonds the funds owned) and then avoid funds with holdings known to be less liquid.

Research methodology: The study is based on data on US mutual funds from the Morningstar Direct database. The authors made a serial correlation model with an AR(1) process and the lagged effects model vs CAPM model to measure two proxies for liquidity risk for each US high yield mutual fund in our fund universe, in order to identify those funds at particular risk for portfolio illiquidity since the beginning of the COVID-19 pandemic.
Results: it is found that the proposed measures may be an effective tool for selecting high yield funds against liquidity risk. Therefore, they should be considered by investors or analysts as a practical tool to identify funds that might be illiquid.
Novelty: The study focuses on the liquidity risk in US high yield bond mutual funds before and after the outbreak of the COVID-19 pandemic, which was a crisis situation with implications for liquidity risk. The methods used and results achieved may be a basis for studies of other types of funds and markets outside the USA.

Key words: high yield mutual funds, liquidity risk, serial correlation model, lagged effect model, portfolio liquidity, COVID-19 pandemic

JEL classification: G12, G23

Introduction

Liquidity plays a crucial role for the stability of global financial markets and lacking it is the reason for financial crashes (Amihud, Mendelson, Wood, 1990; Buiter, Sibert, 2007; Pástor, Stambaugh, 2003). Sudden liquidity deterioration, such as in the famous cases of Bear Sterns and the Lehman Brothers, forced policy makers to introduce structural monetary changes (Joyce, Lasaosa, Stevens, Tong, 2011; Mishra, Parikh, Spahr, 2020). They heightened the investors' awareness of liquidity risk significance which resulted in the growth of investors' interest in the corporate bond market that seemed more attractive because of the higher liquidity risk premium than the US Treasury bond market. In the decade following the financial crisis we could observe the growth of the corporate bond market where mutual funds became prominent market players (Falato, Goldstein, Hortaçsu, 2021). From 2010 to 2019 such funds received net cash inflows of $2.2 trillion, holding approximately 11% of the US fixed income market, 20% of the corporate bonds market and more than 40% of the high yield bond market (International Monetary Fund, 2021; Investment Company Institute, 2020). This dynamic development was suddenly stopped with the outbreak of the COVID-19 pandemic.

The main goal of this study is to investigate the possible abnormal levels of liquidity risk in US high yield mutual funds that would differentiate the COVID-19 pandemic from

previous periods. Right after the outbreak of the pandemic, in March 2020, the Fed sprang into action, providing massive liquidity to the financial markets. The Fed expanded the constellation of debt instruments that it would accept as collateral for its short-term loans. Historically, the Fed had restricted its operations to bonds of high credit quality. The innovation of March 2020 was to extend loans against corporate bonds as collateral, including some bonds rated below investment grade, including high yield bonds. This way the Fed was solving the liquidity crisis of the US high yield bond market which was affecting the performance of mutual funds holding those bonds in their portfolios. In this study using data on US mutual funds from the Morningstar Direct database we applied the serial correlation model with an AR(1) process and the lagged effects model, to measure two proxies for liquidity risk for each US high yield mutual fund in our fund universe, in order to identify funds at particular risk for portfolio illiquidity before and since the beginning of the COVID-19 pandemic. The results of such a liquidity risk analysis could be used by an investor or an analyst to identify ahead of time funds that may be at heightened risk of potential liquidity problems and then invest in lower-risk funds instead. The investor/analyst could then navigate away from the higher risk funds identified by these models, towards funds with similar investment characteristics but lower liquidity risk (Pastor, Vorsatz, 2020). This is particularly important because – as we observe – there seems to be no difference in the returns (or the risk-adjusted returns) between higher liquidity risk funds and lower liquidity risk funds.

To the best of our knowledge this is one of the still few attempts to study liquidity risk in US high yield bond mutual funds during the COVID-19 pandemic. The inflow of the liquidity risk on the market is well documented for the stock market, either before or after the outbreak of the COVID-19 pandemic (Brunnermeier, Pedersen, 2009; Chebbi, Ammer, Hameed, 2021; Foley, Kwan, Philip, Ødegaard, 2021; Zaremba, Aharon, Demir, Kizys, Zawadka, 2021). Bonds (and among them corporate bonds) represent liquidity levels that are markedly different than stocks (Edwards, Harris, Piwowar, 2007). Both types of assets are held by investors who are subject to different regulatory, capital, and funding liquidity constraints (Bali, Subrahmanyam, Wen, 2021). The intertemporal relation between expected return and risk in the bond market is significantly positive (Bai, Bali, Wen, 2021). However, in times of high market uncertainty this relation may change drastically mainly due to the abnormal liquidity risk levels that affect the actions of investors, dealers and financial regulators (Bao, Hara, (Alex) Zhou, 2018; Bessembinder, Jacobsen, Maxwell, Venkataraman, 2018; Di Maggio, Kermani, Song, 2017). This was also characteristic for the time of the COVID-19 outbreak in the United States in early March, 2020 (Kargar et al., 2021). Falato et al. (2021) noticed that during a few weeks the

values of corporate bonds experienced great drops and the funds holding those bonds suffered great outflows. These outflows were most severe for funds with illiquid assets, vulnerable to fire sales, and exposed to the COVID-19 affected industries. Ma, Xiao and Zeng (2022) and Jiang, Li, Sun and Wang (2021) found the fragility in corporate bond mutual funds spilled over into the assets they hold, especially when they were conducting considerable maturity transformation. Nozawa and Qiu (2021) and O'Hara and Zhou (2021) studied the impact of the Fed's unprecedented initiatives to support the corporate bond markets that brought back the stability of performance of funds that hold these securities.

This study complements previous findings and refers to this stability by looking for abnormal liquidity risk levels in US high yield bond mutual funds that could predict the March, 2020 liquidity crisis. We used two proxies for liquidity risk: the serial correlation of returns as well as latent beta and we checked – fund by fund – the liquidity risk levels before and after the outbreak of the COVID-19 pandemic. Our proxies became simple tools utilized to identify funds that might be illiquid. After this identification an investor or an analyst decides about removing it or not adding to the portfolio he/she owns or manages. We believe that the results of our study are both applicable in reality and informative for the potential mutual fund investors and mutual funds themselves, not only the US ones.

The remainder of the study is as follows: In Section 1, we describe the historical background for liquidity risk in the US high yield bond market. In Section 2, we present the data and describe the methods; in Section 3, we present the details of our findings, and in Section 4 we conclude.

1. The background for liquidity risk in the high yield bond market

Many pension funds and other institutional investors, including mutual funds in the US have long-lived liabilities and therefore have an exceedingly long investment horizon. There is a dearth of financial assets that have the duration that these investors require for their portfolios. Besides having long horizons, these investors also have huge amounts of money to invest, resulting in a liquidity surplus and a shortage of suitable fixed income papers. This has led to today's situation, where the amount of issuance of corporate debt, both investment grade and junk grade, exceeds the levels issued in previous years, as depicted below in Figure 1. Even with the uncertainties surrounding the path of the COVID-19 pandemic and the growth of the US economy, the demand for newly-issued corporate debt, even junk debt – even at relatively narrow credit spreads – is at record levels see (Figure 1).

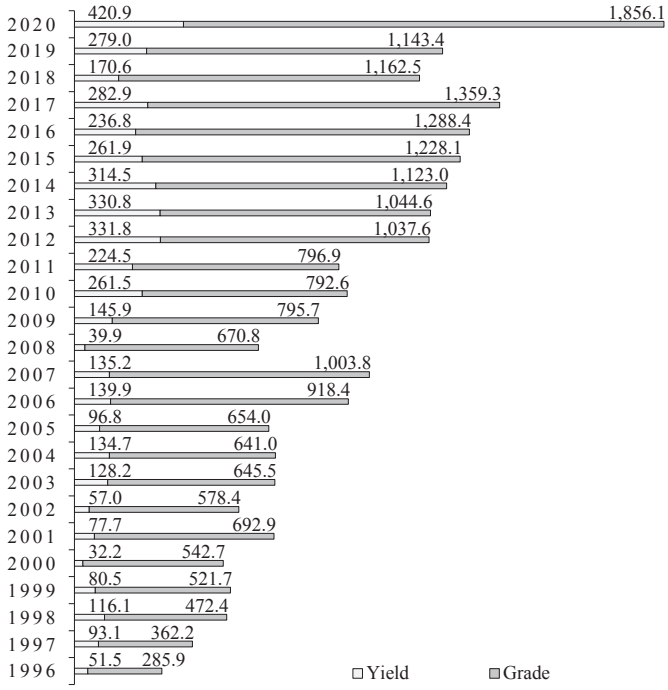
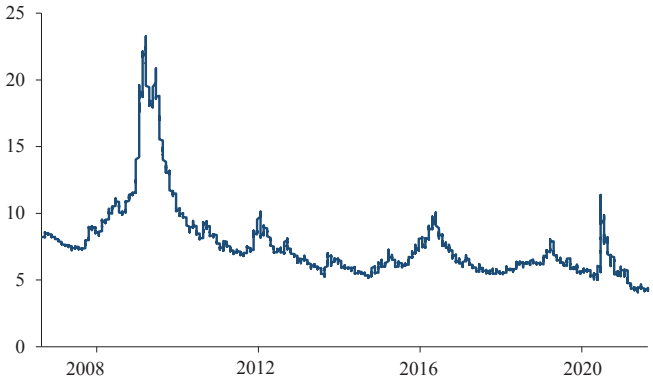


Figure 1. US Corporate Bond Issuance (in billions USD)

Source: Rifinitive, after: SIFMA Research (www.sifma.org).

In addition, the compensation to investors measured as spread over the credit-risk-free US Treasury yield curve is at very tight levels (Figure 2). So, how can we be worried about liquidity risk when there is ample liquidity and investors cannot get enough of the paper? It is the paradox of the "macro" new issuance liquidity which is obviously plentiful, and the "micro" secondary market liquidity which is questionable and varies by the fund.

The institutional investors mentioned above buy bonds to hold to maturity. They are not interested in trading them or selling them in a large size – after all, they already have too much money to spend – if they sell bonds, then they will just have even more cash to invest. There is macro level liquidity in the sense of plenty of money to buy up new issuance bonds. But there seems not to be enough micro liquidity in the sense of being able to sell bonds in the secondary market without having a big impact on prices – which is the type of liquidity that high yield mutual funds require.



Daily close, not seasonally adjusted

Figure 2. ICE BofA US High Yield Bond Index Effective Yield (%)

Source: FRED St. Louis Fed (2021).

The bonds that pension and big institutional investors buy to hold to the maturity date have specific maturity dates. Yet, a high yield bond mutual fund, as an investment vehicle, has no maturity date. The fund is perpetual, and the mutual fund will vary in size as fund investors allocate to (or away from) the high yield sector. When a recession comes and the economy slows, high yield bond issuing companies find that their cash flows shrink and their coverage ratios diminish, along with their future prospects and credit standings. In that environment, fund investors will redeem from high yield mutual funds, forcing high yield fund managers to sell bonds within a day or two. This is the micro level liquidity risk that we need to be mindful of and that investors should take into consideration when deciding which funds to buy, at what spread levels to buy, and how much of the portfolio to allocate to this inherently illiquid asset class.

In order to understand the micro level liquidity risk issue, let us illustrate it with an example of a high yield fund over the past 15 years before Covid-19. In Figure 3 we present the 36-month rolling AR(1) Beta (a proxy for the liquidity risk level) for the US SEC-registered mutual fund "Vanguard High-Yield Corporate Bond Fund" known by its ticker VWEHX. This is a $30 billion bond fund with a 40+ year history, which emphasizes higher credit quality and lower risk than are typical of other high-yield funds. This fund has an AR(1) Beta measure that is very near the low end of all high yield funds in our universe (Figure 3).

Looking at Figure 3, the spikes in the AR(1) measure occur when the market suffers a shock, usually a drop in price. We can identify four such shocks that have rocked the high yield bond market in the past fifteen years. First is the June/July 2007 crisis around the failure of two Bear Stearns bond funds, at the beginning of the Global Financial Crisis. About a year

later, the larger shock was the collapse of the Lehman Brothers. More recently, the turmoil in the stock market in the 4Q of 2018 also affected the market for high yield bonds. And lastly, we indicated the March 2020 COVID-19 stock market collapse, which also affected high yield bonds as a general crisis of market liquidity, which the Fed rushed in to solve.

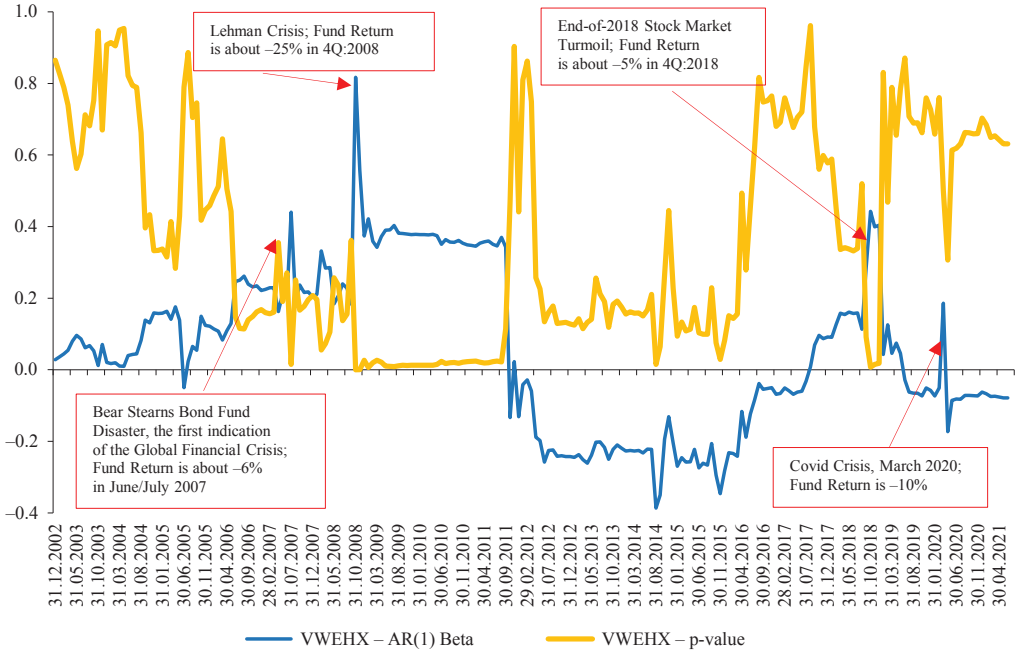


Figure 3. 36-month rolling AR(1) Beta and p-value for the VWEHX fund

Source: own calculations based on fund return data from Morningstar Direct.

Note in Figure 3 that these four episodes led to spikes in the AR(1) Beta measure, but with a nearly immediate drop back down to lower levels. The shape in the graph was obtained due to the way that the 36-month rolling window works. The large negative return enters the 36-month window in the month it happens, but only in the Y-variable in the regression in the first instance. The large negative return enters the X-variable data set one month later, which allows the 36-month rolling window calculation to return to something closer to its normal level. Therefore, as we look at the measure, the point is not to focus on the spikes, but to look for trends in the data in general, and to search for levels of serial correlation (i.e., liquidity risk) in different market regimes.

After the Lehman shock, and for about 36 months until the large negative monthly returns passed through the data sets, the level of serial correlation was measured at about 0.40, with great statistical significance as shown by the very low p-values. One interpretation might be that there was some level of liquidity risk in high yield bonds during this prolonged period. But a different explanation might be that the high yield funds were in a trending phase (as opposed to a mean-reverting phase), posting month after month of positive returns, in recovery from the huge price drops suffered in the wake of the Lehman collapse. Such trending of performance can also cause such a serial correlation measure.

After the prolonged recovery in prices, with the rally fueled by low interest rates, the market entered a period of mean-reverting return performance for about three years, as shown by the AR(1) Beta hovering around –0.25.

Next Figure 4 compares the progress in VWEHX serial correlation to macro level liquidity. Here, we can see that the development of the serial correlation measure over time is indeed related to liquidity, but perhaps overall market liquidity. After hovering around –0.25 for a few years while the Fed Funds rate was held near zero, the serial correlation measure increased as the Fed withdrew liquidity and raised the Fed Fund rate gradually from 0.25% to 2.5%. The stock market finally threw a fit in the fourth quarter of 2018, and the Fed Chairman Jerome Powell reversed course, dropping rates. We can see the renewed liquidity is reflected in the high yield market, with the liquidity risk proxy dropping back to about –0.10, and staying there (except for the March 2020 spike) for the past two years or so.

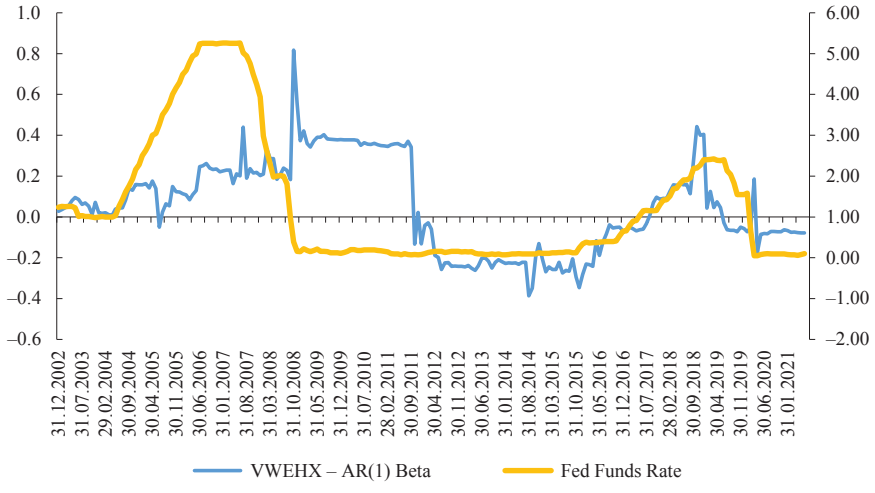


Figure 4. 36-month rolling AR(1) Beta VWEHX fund and Fed Funds Rate

Source: own calculations based on fund return data from Morningstar Direct.

In March 2020, when the US financial markets were in the grip of the COVID-19 crisis, the Fed instituted various policies and programs to alleviate stress in the financial markets. One such program involved the Fed purchase of securities and ETFs in certain market segments, including high yield bonds. This buying action inspired investors to join the Fed (or front-run the Fed) in the high yield bond market, resulting in the tightening of spreads in that market to historically tight levels. That was an inspiration to study possible signals of abnormal levels of liquidity risk in the US high yield mutual funds before and after the outbreak of COVID-19.

2. Data and methods

Our data set is composed of monthly returns for mutual funds located in the United States that Morningstar has classified as High Yield Bond mutual funds in the Morningstar database. Our initial population contains 175 investment funds active since 1/31/2000 to 5/31/2021. Because of missing monthly returns and the concentration on pre-and after COVID-19 outbreak period that does not necessarily cover the Global Financial Crisis we narrowed our universe to the 117 high yield mutual funds from the database that have a return history covering the period 6/30/2011 through 5/31/2021 (120 months) and that are correctly classified as high yield bond funds[1] to recognize behavior appropriate to mature funds and avoid a "new fund" bias. The summary statistics of the research sample is presented in Table 1.

Table 1. Summary statistics on the US High Yield Bond mutual funds

Number of funds	117
Average excess monthly returns (%)	+0.45
Standard deviation of ex. monthly return (%)	1.97
Median excess monthly return (%)	+0.51
Minimum excess monthly return (%)	19.30
Maximum excess monthly returns (%)	+18.20
Average size (30.07.2021) [bn $]	2,423.9
Minimum size (30.07.2021) [mn $]	17.00
Maximum size (30.07.2021) [bn $]	29,645.3

Source: own calculations.

[1] We omitted one mutual fund classified by Morningstar as High Yield that is probably actually a Liquid Alternative fund, in that the fund operates as a fund of funds, uses significant leverage, prices its management fee as a Liquid Alternative fund (i.e. very high fee), and does not own bonds.

The histogram of the excess monthly return of investigated funds is presented in Figure 5.



Figure 5. Excess monthly returns of investigated funds

Source: own calculation based on monthly holding period returns of studied funds.

For each fund in the universe, based on the 120 monthly holding period returns, we calculated an array of statistics and measures to gauge fund performance and fund liquidity risk. These measures are calculated on a 36-month rolling window basis in order to investigate signals of changing levels of liquidity risk over time. We agree with Van Horne (2016) and use two types of proxies for liquidity risk in the underlying portfolios of US high yield mutual funds: serial correlation and lagged effects models.

First we measure the serial correlation, i.e. AR(1) "Beta". We use this measure after Getmansky Lo and Makarov (2004) as the proxy for liquidity risk that is the slope coefficient β_i^{AR} of a one period lagged autocorrelation AR(1) process model:

$$r_{i,t}^{*} = \alpha_i^{AR} + \beta_i^{AR} r_{i,t-1}^{*} + \varepsilon_{i,t}^{AR} \tag{1}$$

where $r_{i,t}^{*} = r_{i,t} - R_t^F$ is an excess return of a fund *i* in time *t* and R_t^F denotes U.S. Treasury bill rates.

The reasons for using AR(1) as a proxy for liquidity risk are as follows. Getmansky Lo and Makarov (2004), working with hedge fund historical monthly return data, developed and estimated a model of "smoothed" returns. In the context of hedge funds, the smoothing

of returns can result from various sources, such as: a) the characteristics of the portfolio assets themselves and the investment strategy or style (e.g., small cap stocks are less liquid than large cap stocks); b) the method of pricing the portfolio at month end (e.g., using models that rely on, say, credit spreads, to price assets can result in some "stickiness" of month-ed pricing from one month to the next, versus simply taking the last traded price from the stock exchange for a liquidly traded stock; and c) deliberate action on the part of the fund manager in assigning month-end prices that smooth returns to understate volatility or to turn small monthly losses into small gains. Smoothing due to any of these three reasons can be detected in an elevated level of serial correlation in the monthly holding period of the hedge funds in the Getmansky Lo and Makarov (2004) study. In the case of high yield funds, some of the holdings can be difficult to price at month-end, especially in less liquid issues, leading to a situation where the AR(1) measure can be a good proxy for liquidity risk. Similarly, high yield bonds as an asset class are in general not as liquid as high grade or US sovereign bonds, so again AR(1) can be a good proxy for liquidity risk.

In the next step we calculate a simple CAPM Beta versus the SP500 that is given with the following equation:

(2)

where $r_t^M = SP500_t - R_t^F$ denotes excess market return.

We assume this beta is an average beta that should be achieved when the markets are calm. We can subtract the value of this beta from the AR(1) Beta (and further the lagged Beta) in order to generate an "excess" beta.

The next stage is to calculate the liquidity risk according to the second proxy measure. We follow Asness, Krail and Liew (2001) who use for this purpose the lagged effects model where they measure the power of an index (or market or benchmark) return to explain the return of a particular fund on a contemporaneous basis and also on the basis of time lags. The model is as follows[2]:

$$r_{i,t}^{*} = \alpha_i^{LAG} + \sum_{k=0}^{3}\left(\beta_{i,k}^{LAG} r_{t-k}^{M}\right) + \varepsilon_{i,t}^{LAG} \tag{3}$$

where $\sum_{k=0}^{3}\beta_{i,k}^{LAG}$ represents the total beta from lagged effect model.

[2] For convenience and ease of explanation, we have included the SP500 index as the explanatory variable in Equation 2; in practice, one could vary this as appropriate.

In addition to the two models to estimate the liquidity risk of the individual funds, we also employed two models to estimate the risk exposures (i.e., betas) and the Alpha of each fund. The first is a simple CAPM with the benchmark (i.e., independent variable) being VWEHX, the Vanguard High Yield Fund:

$$r_{i,t}^{*} = \propto_i^V + \beta_i^V r_t^V + \varepsilon_{i,t}^V \tag{4}$$

where $r_t^V = VWEHX_t - R_t^F$ is excess benchmark return.

The second is a multi-risk-factor model to estimate fund Alpha accounting for interest rate, credit, and equity risks:

$$r_{i,t}^{*} = \propto_i^M + \beta_i^M r_t^M + \beta_i^{SMB} SMB_t + \beta_i^{HML} HML_t + \beta_i^{MOM} MOM_t +$$
$$+ \beta_i^{UST} 10yrUST_t + \beta_i^{BB} \left(10yrUST - BB\right)_t + \beta_i^{EME} EME_t \tag{5}$$

where SMB, HML and MOM refer to the three equity-risk factors in the Carhart 4-factor model (Carhart, 1997), based on the Fama-French 3-factor model (1993): small cap stock premium, value stock premium, and momentum factor. While 10yrUST are the monthly returns to US Treasury bonds to represent interest rate risk exposure the next factor is the monthly returns to the spread of high yield bonds to no-credit-risk government credits to represent credit risk exposure. The last factor is the monthly returns to emerging market equities to represent international equity risk exposure.

The results based on those models allow us to conclude about the informative characteristics of the proxies of liquidity risk for high yield mutual funds. The Python code that we used can be found in the open repository at https://github.com/szymczyklp/LiquidityRisk.

3. Empirical Results

3.1. Estimating Liquidity Risk in the Serial Correlation Model

We calculated the 36-month rolling returns for all funds, as well as the AR(1) Beta and the associated p-values for all funds. We then sorted the funds into deciles based on AR(1) Beta liquidity risk proxy, and similarly sorted funds into deciles based on return. In Table 2 we present the funds which constitute the top decile of funds by the AR(1) Beta proxy for liquidity risk in our universe in the 36-month period ending May 31, 2021[3].

[3] Since 4.30.2019 to 5.31.2021, we exclude mutual funds that have been operating too shortly to calculate AR(1) beta at least in 24 months within the indicated COVID-19 period under consideration (26 months).We exclude mutual funds that have been operating too shortly to calculate AR(1) beta at least in 30% for months within the considered period.

Table 2. Ranking of top decile funds by AR(1) Beta proxy for liquidity risk

Ranking for May 2020 to May 2021 by AR(1) Beta among 117 Funds in Universe	Fund Ticker	AR(1) Decile to May 2020 to May 2021	AR(1) Decile in 2015	Return Decile May 2020 to May 2021
1	PHYSX	1	4	4
2	MNHYX	1	4	1
3	OSTIX	1	3	9
4	WRHIX	1	2	10
5	SHYAX	1	4	3
6	HIIFX	1	2	2
7	PGHYX	1	1	8
8	DLHYX	1	2	6
9	SGYAX	1	3	2
10	ANHIX	1	5	4
11	TYHYX	1	4	10
112	VWEHX	10	10	4

Source: own calculation.

These eleven funds constitute the top decile of possible liquidity risk in the times of COVID-19 (as proxied by the average for AR(1) Beta across the 36-month periods ending May 31, 2020 through May 31, 2021). We find it interesting to note that most of these eleven funds were also relatively high in possible liquidity risk in 2015, immediately prior to the Third Avenue disaster[4]. Yet, when it comes to their recent returns, the average return decile across these eleven top decile liquidity risk funds is the sixth decile – possibly worse than random. In Figure 6 we have included the Vanguard High-Yield Corporate Fund for comparison, in the lowest decile for liquidity risk and in the fourth decile for recent returns.

[4] Third Avenue Focused Credit Fund was a high yield bond fund that suspended daily redemption rights for investors in December 2015. This is a violation of the essential SEC-requirement that funds provide daily liquidity to fund investors. This led to the winding-up of the fund and large losses to investors. The cause of the problems with Third Avenue was that its managers invested too large a portion of the portfolio into illiquid high yield credits. Interestingly, the AR(1) Beta measure for the fund shot up to very high levels compared to out high yield bond fund in early 2015, about nine months prior to the disaster. Investors who were watching the AR(1) measure for high yield bond fund as a harbinger of portfolio illiquidity could have seen the risk coming months ahead of time and could have switched from Third Avenue to a different high yield bond fund. We think there were no investors who were doing this at the time.

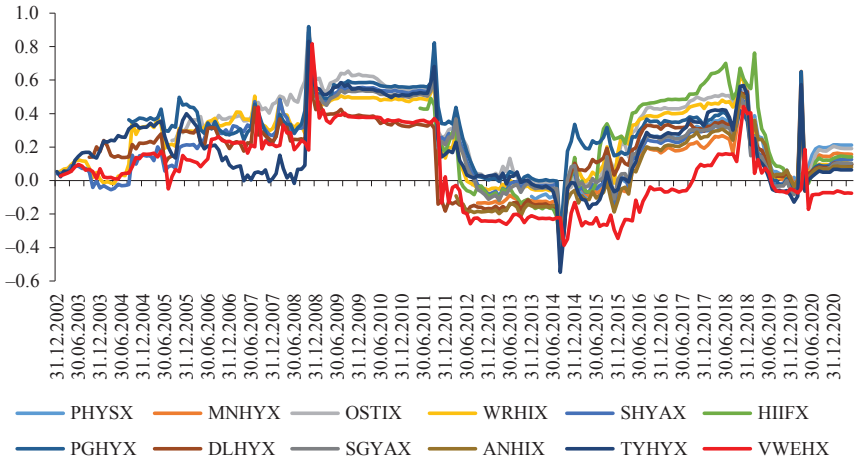


Figure 6. 36-month rolling AR(1) Beta for Top Average Decile AR(1) Beta funds and VWEXX

Source: own calculations.

This figure shows the 36-month rolling window AR(1) Beta liquidity risk proxy for each of the top decile funds from 2002 through May 2021, or from a fund's inception if later. Our benchmark VWEHX is shown with a red dotted line for comparison. We accept and propose VWEHX as a no-liquidity-risk high yield fund, due to the fact that it is in the 95th percentile among the 117 funds in our universe by the AR(1) Beta measure. So, we should expect all the top decile funds to graph higher on the AR(1) Beta than VWEHX, and they do. As a practical tool, this kind of graphing exercise could serve a very useful purpose for the investor. If the investor owns a fund that starts trending higher and higher in this proxy measure for liquidity risk, then the investor could use that as an early warning signal to do further research or even switch to a different fund.

3.2. Benchmarking to VWEHX

Next, we estimated the Alpha for each of the top decile liquidity risk funds in comparison to the VWEHX fund serving as a benchmark, VWEHX being a large, long-historied mutual fund with an expense ratio of just 0.23% in a sector where the average high yield fund charges 0.95%. The results are interesting and are presented in Table 3.

Table 3. Alpha values of the top decile of studied funds

Fund Ticker	Alpha (%)	p-value	Beta	p-value	R^2
PHYSX	–0.49	0.4444	1.1834	0.0000	0.9330
MNHYX	0.18	0.8106	1.0618	0.0000	0.8873
OSTIX	1.41	**0.0270**	0.5717	0.0000	0.7724
WRHIX	–1.02	0.3329	1.1223	0.0000	0.8240
SHYAX	–0.35	0.6755	1.1194	0.0000	0.8795
HIIFX	–5.08	**0.0338**	1.3029	0.0000	**0.5555**
PGHYX	–3.81	**0.0053**	1.3725	0.0000	0.8120
DLHYX	0.61	0.3761	1.0378	0.0000	0.9053
SGYAX	0.29	0.7213	1.1203	0.0000	0.8843
ANHIX	–0.09	0.8983	1.1008	0.0000	0.9047
TYHYX	–2.06	0.0689	1.2708	0.0000	0.8410

Source: own calculations.

Let us start with the p-values of the Alpha measures. Using a 95% confidence level, we can conclude fairly well that eight of the eleven top decile liquidity risk funds have Alpha that is not different than zero, statistically speaking. Of the remaining three funds, two have Alpha that is negative to such a magnitude that we can conclude that it is negative and non-zero, statistically speaking. Only one fund exhibits positive Alpha that is statistically significant.

Next, we can look at the Beta. Eight of the funds have Beta that exceeds 1.0. This makes intuitive sense to us, as we know that the benchmark fund, VWEHX, emphasizes high credit quality. These eight funds must be more typical high yield funds, holding lower quality credits, exhibiting more risk and hence Betas exceeding 1.0 in relation to VWEHX.

Lastly, we can look at the R^2. Similar to looking at the Beta, the R^2 reveals something of the nature of these top decile liquidity risk funds. Ten funds have R^2 of about 0.80 or more – that is, the simple CAPM using a fairly generic high yield fund as the market proxy explains the vast portion of the variation in fund performance for ten of the eleven funds. One fund has quite a low R^2 at 0.5555, indicating that some relevant risk factors may be missing from the model. Yet, as this fund's Alpha is so hugely negative, it may not be worth further investigation.

One could suppose that we are an investor who wants to add a high yield fund to our portfolio. OSTIX should merit some consideration, as its Alpha is positive, its Beta (i.e. its high yield market risk) is low (though its liquidity risk may be high), yet the R^2 shows it is probably a high yield fund of some sort. Though if there is a fund in the universe with similar Alpha and less possible liquidity risk, that may be preferable. If we were to identify the risk factors that are

missing from this simple CAPM and get a higher model R^2 for OSTIX, then likely the Alpha will shrink or disappear as we identify more of the return to be compensation for bearing some as-yet-not-identified risk, and not actually Alpha.

3.3. Estimating Liquidity Risk in the Lagged Effects Model

In the next step, for each fund, we summed the four Betas versus the SP500 from the lagged effects model of Equation 3, and then subtracted out the CAPM Beta versus the SP500 from Equation 2. The result is an estimate of the latent Beta that may be due to "sticky" pricing, that is, a proxy for liquidity risk in these high yield mutual funds. Figure 7 shows the average of this measure across the 117 funds in the universe, and also for the VWEHX fund. Note that in the era of the COVID-19 pandemic, this measure of proxy liquidity risk abruptly changed, from a negative to a positive level of latent Beta. In Figure 8 we can look at the individual funds on the top decile of liquidity risk by latent Beta. We can observe the difference in the scale between the two charts. The average latent Beta among the 117 high yield funds in the COVID-19 era is about 0.10 to 0.20, whereas for the top decile funds by latent Beta the measure is much higher, in the range of 0.25 to 0.45.

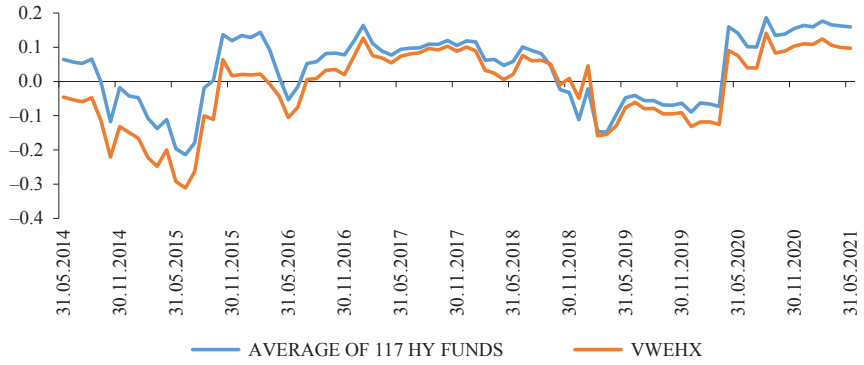


Figure 7. Average value of latent Beta for high yield funds

Source: own calculations.

In Figure 8 we can look at the individual funds on the top decile of liquidity risk by latent Beta. We can also observe the difference in scale between the two charts. The average latent Beta among the 117 high yield funds in the COVID-19 era is about 0.10 to 0.20, whereas for the top decile funds by latent Beta the measure is much higher, in the range of 0.25 to 0.45.

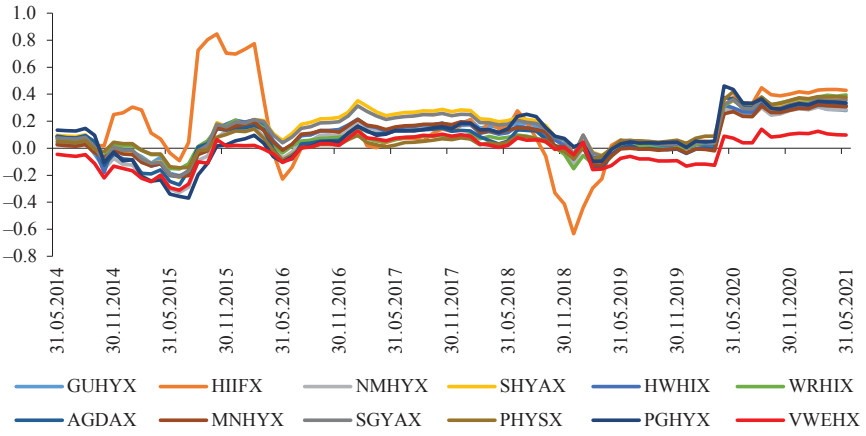


Figure 8. Values of latent Betas for funds in the top decile and VWEHX

Source: own calculations.

We have now added to the Figure 8 chart the high yield bond spreads, the extra return over the US Treasury curve as compensation for credit risk for high yield bonds is shown on the right-hand scale of Figure 9.

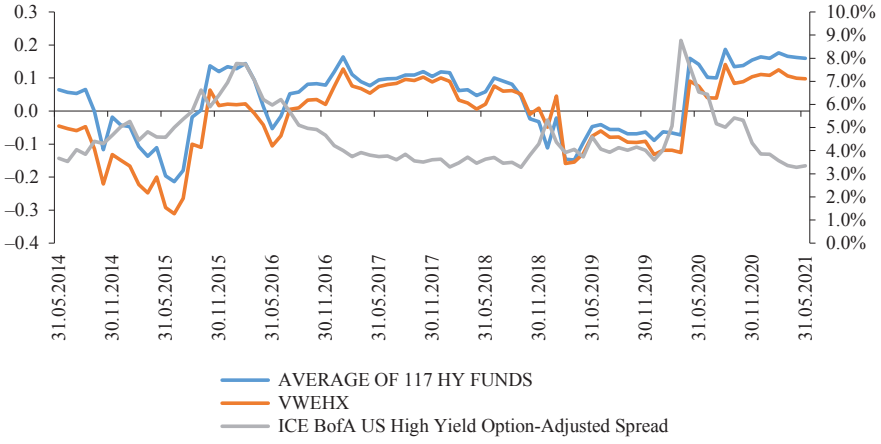


Figure 9. Latent Betas for funds in the top decile and VWEHX in relation to high yield spreads

Source: own calculations.

These spreads were at historic low levels in the middle of 2021, at about 3.3% per annum in extra yield for taking the credit risk of non-investment grade credit. When the spread plunged

from 8% to about 4% starting in 2016, the Latent Beta measure of the high yield bond sector rose to about 0.10. When the spreads dropped from about 8% to about the level of 3.3% which started in 2020, the Latent Beta measure again rose, this time to about 0.15 for high yield bonds on average. Tight spreads brought on by the Fed monetary policy or by the massive demand for long-duration fixed income instruments or some combination of the two seem to be associated with higher levels of latent Beta, a proxy for market liquidity risk.

Also interesting to note is the consistency between the two liquidity risk proxy measures: AR(1) Beta, and the lagged effects model's latent Beta. The details of this analysis is presented in Table 4. Of the eleven funds in the top decile by latent Beta, seven are also in the first decile by AR(1) Beta and three more are in the second decile by AR(1) Beta. It seems that the consistency between the two liquidity proxy measures is especially strong for the funds with the most liquidity risk, in the top three deciles.

Table 4. Places of studied funds in the deciles according to latent Beta and AR(1) Betas

Decile by Latent Beta	Average decile for these funds by AR(1) Beta
1	1.9
2	2.8
3	3.7
4	5.2
5	5.9
6	8.1
7	6.3
8	7.1
9	6.8
10	7.3

Source: own calculations.

3.4. Is There a Return Associated with Bearing Liquidity Risk?

To examine the relationship between liquidity risk and return, we regressed fund returns on fund AR(1) Beta liquidity risk proxy for the 36-month period ending May 31, 2021. The results show the model not to be valid, with the R^2 near zero, and a significance F and p-value for the slope of 0.70. It seems there is no systematic relationship between fund returns and the AR(1) Beta liquidity risk proxy in the COVID-19 era (nor in earlier time periods) in the high yield bond market. Similarly, a regression of fund returns on fund latent Beta as estimated in the

lagged effects model shows there is no systematic relationship between fund returns and latent Beta liquidity risk proxy in the COVID-19 era.

Next, we estimated the Alpha for each fund in comparison to the VWEHX fund serving as a benchmark. Just a reminder, VWEHX is a large, long-historied mutual fund with an expense ratio of just 0.23% in a sector where the average high yield fund charges 0.95%. We then categorize the funds as: a) "has positive Alpha" (Alpha > 0% and p-value < 0.05; b) "has negative Alpha" (Alpha < 0% and p-value < 0.05); and c) "no Alpha" (p-value > 0.05). The results are shown by decile of liquidity risk proxy, first for the deciles by AR(1) Beta in Table 5, and further for the deciles by latent Beta in Table 6.

Table 5. Values of Alpha of funds in different deciles of AR(1) Beta

Decile by AR(1) Beta	"has positive Alpha"	"has negative Alpha"	"no Alpha"
1	1	2	8
2	1	4	6
3	0	5	7
4	0	4	8
5	0	3	9
6	2	2	7
7	0	3	9
8	0	3	9
9	0	3	9
10	0	1	10

Source: own calculations.

Table 6. Values of Alpha of funds in different deciles of latent Beta

Decile by Latent Beta	"has positive Alpha"	"has negative Alpha"	"no Alpha"
1	0	2	9
2	0	2	10
3	0	6	6
4	1	3	7
5	0	5	7
6	0	4	8
7	0	3	8
8	0	3	9
9	1	2	9
10	2	0	10

Source: own calculations.

There are a few points to note. Firstly, of the 117 funds that we regressed against VWEHX to estimate Alpha, only four funds (that is, about 3.5% of the funds in the universe) exhibited a positive Alpha. Stated differently, investors in 96.5% of the funds in the high yield mutual fund universe would likely have been better off, on a risk adjusted basis, to simply invest in the low cost, plain-vanilla, Vanguard group high yield bond fund. Secondly, about 71% of the funds in the universe have no measurable Alpha (that is, the p-value for the intercept in the regression is not statistically significant at the 95% confidence level, so we can conclude that the Alpha is not different than zero). These are well distributed across the deciles of liquidity risk, either proxied by AR(1) Beta or by latent Beta. That means that there are plenty of mediocre funds in all liquidity risk deciles. Thirdly, since there are only four funds that have statistically significant positive Alpha, it is not clear that there is any relationship between Alpha and the liquidity risk decile. Finally, there are 30 funds (about 25% of the universe) that have statistically significant negative Alpha. These funds actually destroy shareholder value in relation to the investor's opportunity to invest in a low-cost high yield bond fund such as the Vanguard group fund. Just by visual inspection, it seems that these funds tend to reside in the higher liquidity risk deciles, though this tendency is not obvious.

Applying the lagged effects model to the high yield bond fund sector yields interesting results. From Figure 3 above, we can see that high yield bond funds in general have a higher level of imputed liquidity risk in the COVID-19 era. This could be the result of the Fed's provision of massive liquidity to the financial markets in general, and to the Fed's purchase of corporate sector bonds in particular. It seems that price determination has been impeded by the liquidity provision as well as by the actual purchases (and the assumption that additional purchases could materialize in the event of further destabilization) of bonds by the Fed. Market participants know that the Fed has been buying, and that the Fed may come to buy more later in case of need. This distorts price discovery, keeps bonds prices higher than the underlying credit situation warrants, and likely diminishes liquidity, raising liquidity risk.

Looking at certain funds in particular – the top decile of funds by latent Beta allows us to identify the funds that have the greatest liquidity risk. We can see that there is no commensurate compensation for investors to own these funds. The top decile by latent Beta contains no "has positive Alpha" funds, two funds with negative Alpha, and nine with no measurable Alpha. Similar results are obtained, as explained above, in the case of the top decile of funds by AR(1) Beta. We may conclude fairly well that investors should shop for high yield mutual funds in the lower liquidity risk deciles, as there seems to be no particular compensation for bearing liquidity risk in the high yield market.

3.5. A Robustness Test on Compensation for Bearing Liquidity Risk

We ran also a 7-factor model – as shown in Equation 5 above as a kind of robustness test. In this way we receive 7-factor Alpha $\propto_i^M$, adjusting for equity risks, interest rate risks, credit spread risks and intl equity risk. In this approach you can check that for all funds we received $\propto_i^M < \propto_i^V$ and a lot more mutual funds from our Universe had positive $\propto_i^M$ (89 mutual funds) compared to the VWEHX benchmark model $\propto_i^V$ (20) – that is, the Vanguard is a higher bar to jump over to prove Alpha.

Conclusions

In this paper we have applied the serial correlation and lagged effects models, to see how the US high yield bond mutual fund sector has responded in general to the changes to monetary policy in the COVID-19 era. We have found that the proposed measures may be an effective tool for selecting high yield funds against liquidity risk. At the micro level, an investor could usefully employ these models in fund evaluation and fund selection, avoiding funds with higher levels of imputed liquidity risk in the absence of compensation in the form of higher return or positive Alpha for bearing this risk. Our logic is in line with the previous study of Fall, Louhichi, and Viviani (2019) who argues that investors ask larger premiums for holding illiquid portfolios. That was the case during the beginning of the COVID-19 era as found by Ma et al. (2022) and Jiang et al. (2021). In the absence of those premiums investors were greatly redeeming the US high yield mutual funds as proved by Falato et al. (2021). Concluding, if a particular fund exhibits high levels of serial correlation, and if the source of the measure might be illiquidity in some of the underlying portfolio assets, and if the fund is not providing a return that is higher than other funds in the asset class, then it might make sense for investors to avoid such funds in favor of funds with similar historic returns but lower levels of serial correlation. This was the lesson of the Third Avenue Focused Credit Fund disaster in 2015. And this is a possible practical application of the use of serial correlation and lagged beta as a proxy for liquidity risk.

The limitation but also the advantage of this study are the simple proxies of liquidity risk. Future research should look further into the analytic power of those proxies in the context of fund performance evaluation of high yield bond funds outside the United States or other types of mutual funds (such as liquid alternative funds) from the US or other fund markets. Such research may focus on times of crisis or market stress as well as on the dynamics of illiquidity

in more normal market conditions. This is beyond the scope of the current paper but it deserves to become a topic for future research.

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