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LIQUIDITY RISK MEASUREMENT FOR MUTUAL FUNDS INVESTING IN LESS-LIQUID ASSETS

MIARY OCENY RYZYKA PŁYNNOŚCI FUNDUSZY INWESTYCYJNYCH. ZASTOSOWANIE MODELU KORELACJI Z PROCESEM AR(1) ORAZ MODELU Z EFEKTAMI OPÓŹNIONYMI

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Summary: I apply two models from the existing academic literature to assess liquidity risk in groups of mutual funds as well as in individual high yield mutual funds. These models are a serial correlation model with an AR(1) process and a lagged effects model. These models were most recently applied in the field of hedge fund research to measure liquidity risk and to evaluate the performance of aggregated groups of hedge funds, organized by investment strategy. I apply these models in the recently developing area of liquid alternative mutual funds and at the level of the individual mutual fund. A perceived benefit to investors in the liquid alternative funds is the structural, daily-redemption liquidity of the fund shares. Yet, the liquidity of the underlying securities portfolios held by these funds is not apparent to the investors and may expose the investor to heightened liquidity risk. The models perform well and will be applied to identify liquidity risk in a further ongoing study of the performance and liquidity of individual mutual funds. Liquidity risk assessment should play a vital role in performance evaluation and fund selection.

Keywords: liquidity risk; mutual funds; serial correlation; lagged effects.

Streszczenie: Artykuł przedstawia zastosowanie dwóch znanych z literatury modeli (model korelacji z procesem AR(1) i model z efektami opóźnionymi) w ocenie ryzyka płynności grup funduszy inwestycyjnych oraz pojedynczych funduszy inwestycyjnych, w szczególności rozwijającego się segmentu płynnych alternatywnych funduszy inwestycyjnych. Zaletą tego typu funduszy jest możliwość codziennego umarzania udziałów. Jednak pojawiają się sytuacje niższej płynności tych funduszy, co oznacza dla inwestora większe ryzyko. Badania wskazują na dobre funkcjonowanie obu modeli, co umożliwi ich przyszłe zastosowanie w ocenie działalności pojedynczych funduszy inwestycyjnych. Artykuł wskazuje na kluczową rolę ryzyka płynności w ocenie i wyborze funduszy inwestycyjnych.

Słowa kluczowe: ryzyko płynności, fundusz inwestycyjny; model korelacji z procesem AR(1), model z efektami opóźnionymi.

1. Introduction

The traditional asset classes are stocks, bonds, and cash. The asset classes that are "alternative" to the stocks, bonds, and cash of the traditional portfolios are non-traditional and have come to be known as "alternative assets." These alternatives provide new or different risk exposures to investors, their particular attraction being the diversification benefits of asset classes with a low correlation to the usual equity and fixed income risk factors, as well as the opportunity for higher returns in less efficient market spaces. When these asset classes or strategies are packaged into mutual funds (as opposed to hedge funds) they are known as "liquid alternative funds" since mutual funds offer the liquidity of subscription and redemption on a daily basis.

Historically, investors have accessed these non-traditional risk exposures by investing in these areas through hedge funds. Hedge funds grew to prominence in the 1970s, 1980s, and 1990s as private investment vehicles exempt from United States Securities and Exchange Commission ("SEC") regulation. By refraining from offering the funds to the public at large and from advertising the funds and the funds' performance, among other constraints, the hedge fund managers were able to avoid SEC regulation and to invest with great flexibility, including the use of leverage, the use of derivatives, shorting, and infrequent investor redemption, among other aspects.

The following table contrasts liquid alternative mutual funds and hedge funds on various aspects.

One of the greatest perceived benefits of the liquid alternative funds movement is bringing daily liquidity to hedge fund investment methodologies. Yet, lurking in the daily liquidity requirement may be a danger for investors, that is the risk that a fund's assets may not be liquid enough to support the daily liquidity of the fund's shares, or the risk that heavy investor redemptions could upset the liquidity balance of the fund's portfolio. In fact the SEC last year voted to propose a regime of rule changes aimed at improving liquidity risk management in U.S., SEC-registered, publicly-offered, open-end mutual funds. In undertaking the liquidity risk initiative, the SEC pointed to the development of new areas of the mutual fund business around strategies that deal with securities that are less liquid than the stocks and bonds that populate the portfolios of the traditional mutual funds. In particular the SEC mentioned: a) high-yield bond funds; b) emerging market equity funds; c) emerging market debt funds, and d) alternative strategies[1] funds. The SEC's concern is not just the liquidity aspects of these funds, but also the fact that these types of funds –

[1] The alternative strategy funds mentioned by the SEC are the liquid alternative funds, employing several investment strategies originally popularized in the hedge fund space. Using the Morningstar fund categorization framework, we can identify these in seven areas : multi-alternative funds, long-short equity funds, non-traditional bond funds, market neutral funds, managed futures funds, bear market funds, and multicurrency funds.

Table 1. Comparison of liquid alternative mutual funds and hedge funds

Supervision/regulation of asset management firm	Liquid alternative mutual funds	Hedge funds
	Always: SEC	In most cases: SEC
Supervision/Regulation of the Investment Vehicle/Fund	Heavy	Light
Flexibility of Investment Program	According to prospectus, as approved by SEC	Highly flexible
Liquidity of Underlying Portfolio	No more than 15% permitted in "illiquid" securities	At discretion of asset manager
Use of leverage and derivatives	According to prospectus, as approved by SEC	At discretion of asset manager
Liquidity of the Shares of the Investment Vehicle/Fund	Investors may enter/exit on a daily basis at net asset value; redemptions must be paid in cash in seven days at most (most mutual funds pay as soon as the next business day)	Entry/exit as specified in the fund offering documents, typically annually, sometimes quarterly or monthly. Cash payment of proceeds can take several weeks
Suspension of Redemptions from the Vehicle/Fund	Very rare, and allowed only with specific approval of the SEC	In times of market disruption, at the discretion of the asset manager
Asset Management Fees:	Typically around 2% per annum for "liquid alternative" strategy mutual funds	Typically 2% per annum base management fee, and 20% of the net new investment gains (paid annually), with high water mark

Source: author's own work.

particularly the alternative strategy funds – have grown, and are growing rapidly in the assets under management, in the number of funds, and in the share of overall mutual fund assets.

In this article, I will examine the liquidity risk of liquid alternative funds in their aggregate Morningstar category groups. In Section 2, I will introduce two liquidity risk measurement models from the hedge fund performance analysis literature. In Section 3, I will apply these models to high yield bond funds, one of the areas of potentially heightened liquidity risk identified by the SEC. In Section 4, I will perform a general test of the one of the models, the serial correlation model, in the context of broad equity indices and of the liquid alternative funds in their Morningstar category aggregations. Section 5 summarizes and proposes future research.

2. Liquidity risk measures from the hedge fund literature

Liquidity risk in hedge funds is usually not of immediate concern since hedge funds are due to infrequent redemption rights. Nonetheless, there is in the hedge fund literature two models of liquidity risk assessment that may be useful in the study

of liquidity risk in mutual funds. I refer to the lagged effects model described in [Asness et al. 2001], and the application of a serial correlation model to hedge funds returns in [Getmansky at al. 2004].

Getmansky et al. use an AR(1) process as their serial correlation model:

$$r_{it} = \propto_{iT} + \beta_{iT} r_{it-1} + e_{it}. \quad (1)$$

They identify the presence of serial correlation in funds that invest using various hedge fund investment strategies. They detect relatively higher measures of serial correlation among funds that follow certain investment strategies, that is some investment strategies are more likely to exhibit higher levels of serial correlation than others.[2]

Asness et al. describe a situation where standard regression results "may be misleading [since] many hedge funds hold (…) illiquid exchange-traded securities or difficult-to-price over-the-counter securities, which can lead to non-synchronous price reactions." Further, Asness et al. note that "the presence of stale prices (…) can artificially reduce estimates of volatility and correlational with traditional indexes" [Asness et al. 2001, p. 7]. Asness et al. revive from previous literature [Scholes, Williams 1977; Dimson 1979] a lagged effects model where they measure the power of an index (or market or benchmark) return to explain the return of the particular fund on a contemporaneous basis and also on the basis of time lags. In the analysis of fund performance, this will typically be on monthly data with the time lags being for one, two, and three months as per the [Asness et al. 2001] model:

$$r_{i,t} = \propto_i + \beta_{i,t}(SP500)_t + \beta_{i,t-1}(SP500)_{t-1} + \beta_{i,t-2}(SP500)_{t-2} + \beta_{i,t-3}(SP500)_{t-3} + e_{it}. \quad (2)[3]$$

The Beta that we are familiar with from, say, the Capital Asset Pricing Model or from the Fama-French Three-Factor Model is the contemporaneous Beta, in the case of Equation (3), denoted as $\beta_{i,t}$.

$$r_{i,t} = \propto_i + \beta_{i,t}(SP500)_t + e_{it}. \quad (3)$$

Asness et al. find that funds that invest using various hedge funds investment strategies may exhibit attractively low Betas to the market return on a contemporaneous basis, but higher overall Betas when the contemporaneous reading is augmented with lagged readings. In the case of [Asness et al. 2001], these lagged periods extend three months back, for a total of four explanatory variables, as in Equation (2). Of course, higher overall dependence on the market return for a fund implies less diversification

[2] Also some individual funds may exhibit higher levels of serial correlation without reference to the investment strategy, on an individual fund or idiosyncratic basis, as will be described.

[3] For convenience and ease of explanation, I have included the SP500 index as the explanatory variable in Eq. (2); in practice one could vary this as appropriate.

benefit from that fund and less fund return attributable to alternative (non-market) sources of risk than as measured by a simpler, contemporaneous CAPM regression.

The presence of serial correlation and lags in hedge fund returns can be caused by various factors, as explained by Getmansky et al. and Asness et al., including: a) the fund investment strategy and nature of assets in the fund; b) the method of month-end pricing; and c) the deliberate "smoothing" of returns by the fund manager.

One factor is the investment strategy and the nature of the assets. Large cap equity funds should have low levels of serial correlation. Large cap stocks are liquid, the price at month-end does not have much to do with the price at the end of the previous month. With small cap stocks, one should expect a slightly higher serial correlation and lagged effects. Small cap stocks do not trade as actively as large cap stocks, so the stock's price at a month-end may be influenced by or related to the stock's price at the previous month-end. Hedge fund strategies such as distressed debt may have higher levels of serial correlation and lagged effects than strategies based on liquid equities. Distressed debt may not trade every day, so the pricing may not necessarily be at month-end and can be even more "sticky" than in the case of small cap stocks.

A second factor that can cause serial correlation and lagged effects in hedge fund returns is the method of pricing the portfolio at month-end (which is associated to some extent with the investment strategy and the nature of the assets mentioned in the preceding paragraph). Large cap stocks are easy to price. Just take the last traded price off the stock exchange. In the case of pricing small cap stocks, one still takes the last traded price from the exchange, but the trading is less frequent, so the price may be a bit stale. The pricing may be "sticky" compared to the pricing of large cap stocks, so we may expect to see higher levels of serial correlation. In the case of distressed debt, month-end broker quotes may be based on modeling (e.g. spreads to Treasuries or EV and EBITDA multiples) rather than on actual market transactions. This will lead to a month-end price being somewhat related to the previous month-end's price, and to a higher measure of serial correlation.

A third factor that can cause serial correlation and lagged effects is the deliberate "smoothing" of the returns, which we can think of as a form of manager dishonesty or fraud. A manager might be tempted to "smooth" his/her returns in order to turn a negative performance month into a positive performance month[4] or to reduce the fund's standard deviation increasing the fund's Sharpe Ratio. Many hedge funds

[4] See [Bollen, Pool 2009]. "The authors use 1994-2005 data to create a histogram of monthly hedge fund returns. They find that the frequency of small negative returns is significantly less than expected and that the frequency of small positive returns is greater than expected, indicating a discontinuity in the distribution. Evidence is presented that managers are reporting overly high returns and then reversing the effect in later months. [This] may lead investors to underestimate the risks of hedge funds.", according to a review in the February 2010 issue of CFA Digest by M.E. Ellis, CFA, of St. John's University.

employ third party service providers for pricing, thus taking the month-end portfolio pricing exercise out of the hands of the manager.[5]

Therefore, the use of the serial correlation and lagged effects models can serve two purposes. First, as tools in manager evaluation and risk-reward measurement. We should get out of the habit of looking primarily at a fund's standard deviation as a measure of risk and at a fund's Sharpe Ratio as a measure of fund performance, without also looking at the fund's serial correlation and lagged effects measures. Serial correlation indicates risk, for which investors should demand to be paid. In the presence of high serial correlation, the standard deviation is not a true or complete measure of risk or volatility (or potential volatility). Funds in strategies that tend to have high serial correlation – such as distressed debt, micro-cap stocks, PIPES or fixed income arbitrage – have a greater risk of dislocation and of a large negative performance surprise. In short, for these types of funds, the standard deviation understates the actual risk and the Sharpe Ratio should be of only limited interest. Similarly, for these types of funds, the lagged effects model gives us a better understanding of the fund's real sensitivity to the market or benchmark. To the extent the real market exposure is higher, then the measure of manager value-added (i.e., the intercept in the regression or the manager Alpha) must necessarily be lower, as will be the diversification benefit derived from including the fund in the portfolio.

Second, as tools in liquidity risk measurement of the funds. The main factors giving rise to higher readings for serial correlation and lagged effects (that is, fund strategy, the nature of the assets, and the method of month-end pricing, taken as three conjoined factors) are essentially factors that bear directly on the liquidity of the fund's underlying assets and therefore of the fund itself. While Asness et al. and Getmansky et al. explained and applied these models in the realm of hedge funds, we should be able to apply the models equally well to mutual funds that invest according to hedge fund strategies and to mutual funds that invest in clearly less-liquid types of securities such as small cap stocks, high yield bonds, municipal bonds, and the like.

Significantly, the data requirements for the serial correlation and lagged effects model are very different than the data requirements for other popular methods of liquidity risk measurement used by the SEC and other researchers. The other models require information on fund flows, on the fund's portfolio holdings, and on the liquidity (trading volume and daily price changes) of the individual securities held in portfolio. Such detailed, high quality data is available for US large-cap equity mutual funds, but not necessarily for other types of funds, such as taxable bonds, small cap stock, and muni bond funds, not to even mention liquid alternative funds, high yield bond funds, and emerging market funds. The data requirements for the lagged effects and serial correlation models are the monthly holding period returns for the funds. This data is available for virtually any hedge fund or mutual fund,

[5] Getmansky et al. report that, among the several potential sources of serial correlation in hedge fund return streams, "the most likely explanation is illiquidity exposure and smoothed returns."

irrespective of investment strategy or type of asset held in the portfolio. The analyst can apply these models and assess liquidity risk at fund level across a wide variety of fund investment strategy types.

3. Use of the serial correlation model with individual funds

We want to see if the models are of practical value at the level of the individual fund: in fund evaluation prior to investing, and in fund monitoring after investment. I present here an after-the-fact case study in the potential of the two models in the realm of mutual funds.

On December 9, 2015, an SEC-registered, open-ended, daily-liquidity, US high yield bond fund, the Third Avenue Focused Credit Fund, applied to the SEC for an exception from the mutual fund operating rules, cancelled investors' redemption rights, and suspended the fund's investment operations. This was a truly extraordinary and almost unprecedented move, the Third Avenue fund story was the top story in the business news that day and in the following days. What happened?

When analysts starting paying attention to the fund after the events, we learned quite a bit about the fund, its portfolio, and its liquidity. Martin Fridson is perhaps the most experienced and the pre-eminent high yield bond market analyst on Wall Street. Fridson released a news story on December 15 on the website highyieldbond.com, where he stated: "Ownership of distressed bonds[6] (…) by ordinary high-yield mutual funds is usually inadvertent. The funds sometimes buy seemingly healthy credits that unexpectedly go bad. Occasionally, they decide not to sell, thinking the troubled issuer will turn around, only to wind up holding a defaulted bond. They do not, as a rule, deliberately play in defaulted debt, as was Third Avenue Focused Credit's practice, as that paper generally provides no current yield. (…) High-yield mutual fund shareholders should certainly take a close look at this simple metric (i.e., the proportion of assets in a high yield bond fund's portfolio rated CCC to D or non-rated) (…) Given that 63% of CCC-C issues within the BofA Merrill Lynch US High Yield Index are currently quoted at distressed levels, a ratio approaching TAFC's [high level] would be a strong indication that the fund is in reality a distressed debt player, regardless of how it is classified by SEC rules" [Fridson 2015].

So, while some investors had redeemed from the Third Avenue fund earlier in 2015, many had not and were surprised by – in fact, shocked and outraged – finding themselves trapped in a liquidating trust owning illiquid bonds that would take years to sell. The press and the analysts could write after-the-fact about the details of the Third Avenue fund's portfolio, which were available on the Bloomberg system and in the fund's public filings. But prior to the collapse on December 9, a Google search

[6] Distressed bonds, judged by the low prices and very high implied yields, are bonds that the market expects to default in the coming weeks or months. Distressed bonds are a sub-set of the larger high yield bond market.

reveals no blog posts or reports or news article about the dangers of investing in the Third Avenue fund. Would a liquidity risk measurement tool have been useful in this case? To answer this question, I first created a database of representative high yield mutual funds, as in the Table 2.

Table 2. Peer group of mutual funds and indices

Name of Fund	Ticker	Rationale
Third Avenue Focused Credit Fund	TFCIX	Suspended redemptions on December 9, 2015
Wells Fargo Short-Term High Yield Bond Fund	SSTHX	A short term high yield bond fund; a portfolio that should be highly liquid
Catalyst/SMH High Income Fund	HIIFX	Mentioned in the press in December 2015 as being a fund with poor performance and lower liquidity
Diamond Hill Strategic Income Fund	DSIAX	A high yield bond fund operated by a group active in liquid alternative funds (long short equity)
Fairholme Focused Income Fund	FOCIX	A high yield bond fund operated by Bruce Berkowitz, a prominent value investor
Franklin High Income Fund	FHAIX	A well-known high yield bond fund, mentioned in the press in December 2015 as holding some distressed bonds
Nuveen High Income Bond Fund	FJSIX	Mentioned in the press in December 2015 as being a fund with some distressed bonds
T. Rowe Price High Yield Fund	PRHYX	A large, prominent high yield bond fund with a long history
Vanguard High-Yield Corporate Fund	VWEAX	A large, prominent high yield bond fund with a long history, actively managed by Wellington Management
Blackrock High Yield Bond Fund	BHYAX	A large, prominent high yield bond fund with a long history
Fidelity Advisor High Income Fund	FHIAX	A large, prominent high yield bond fund with a long history
SPDR Barclays High Yield Bond ETF	JNK	Passively managed, index-tracking ETF
BofA Merrill Lynch US High Yield Master II Index	MLHY Index	This is not an investable fund; this is a widely used index of high yield returns
Morningstar US Open End High Yield Bond Category Index	MStar HY Bond	This is an index based on the performance of actual high yield mutual funds, aggregated into an index

Source: author's own work.

Beginning with the inception date of the Third Avenue Focused Fund ("TFCIX") in September 2009 and continuing through December 2015, I assembled the monthly holding period returns for the funds over the period of 76 months. Then I calculated the serial correlation using an AR(1) process and Equation (1) above. I did this on the

basis of 36-month rolling windows, beginning with the September 2009 to August 2012 period and continuing through to the final January 2013 to December 2015 period. In this way, for each fund or benchmark or index, we can track the changes in the 36-month serial correlation measure over time. The results are shown in the Fig. 1.

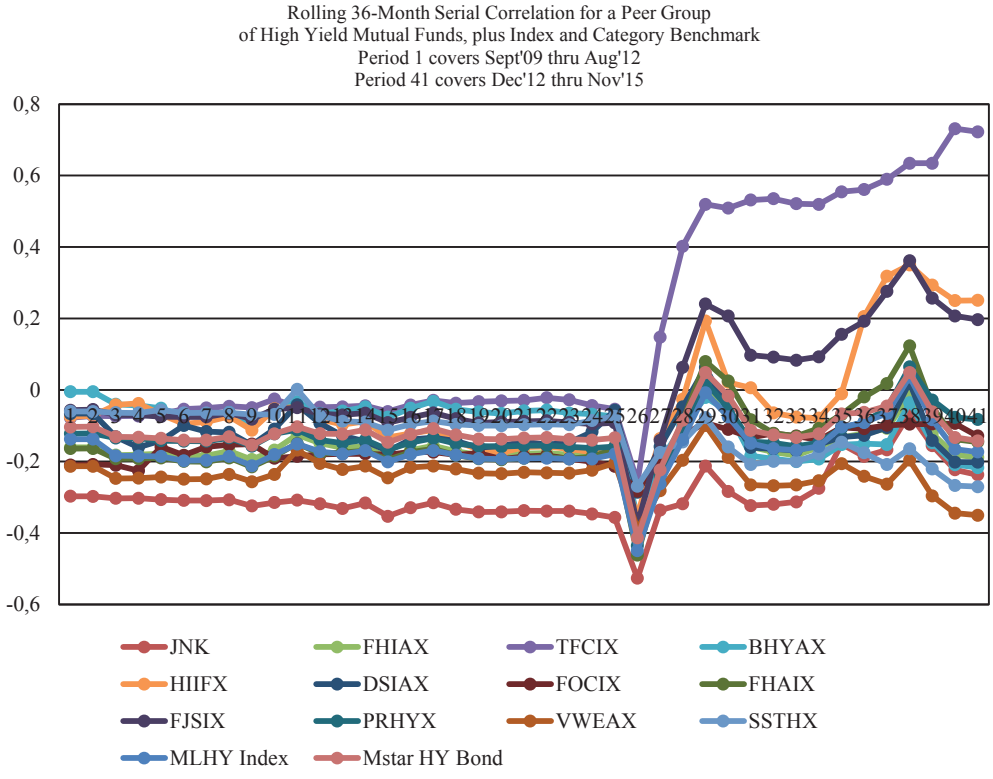

Fig. 1. Rolling 36-month serial correlation of high yield mutual funds and indices

Source: Morningstar for monthly holding period returns [www.morningstar.com], author's own calculations.

Three aspects of this chart warrant mention. First, the series with the consistently lowest measures of serial correlation are: a) the SPDR Barclays High Yield Bond ETF, a passive investment vehicle that tracks the Barclays High Yield Very Liquid Index (so no surprise that this has the lowest liquidity risk of the peer group); b) the Vanguard High-Yield Corporate Fund; and c) the Wells Fargo Short-Term High Yield Bond Fund (focusing on the short term part of the high yield market, so holding bonds that one can expect to be more liquid).

Second, during the first 25 periods of the chart, the relative positions of the various funds does not change very much, with TFCIX fairly consistently exhibiting the highest level of serial correlation in this broad peer group, though not at a level that would indicate any particularly alarming level of liquidity risk. (The bump down at period 26 is a market-wide phenomenon due to the August 2008 data point between period 25 and period 26. August 2008 and September 2009 were two consecutive months of large negative returns of the high yield bond market. Losing the August 2008 reading from the 36-month rolling window causes a drop in the measure of serial correlation.)

Third, there is a steady increase in the apparent liquidity risk for TFCIX starting in period 27. By period 29, the 36-month rolling serial correlation for TFCIX is over 0.50 and clearly much higher than for any other fund in the peer group. Period 29 comprises the 36-month period ending December 2014. The point is that this measure of liquidity risk was sending a strong warning signal to investors about TFCIX in the first days of January 2015, eleven months before the TFCIX suspended investment operations and blocked investor withdrawals. The serial correlation liquidity risk

Table 3. Lagged effects model betas for high yield mutual funds and indices

September 2009 through December 2015 (74 months) Fund/index/benchmark	Lagged effects model, sum of 4 betas to the SP500	CAPM contemporaneous Beta to the SP500	Difference
Morningstar US Open End High Yield Bond Category Index	0.4571	0.3628	0.0943
BofA Merrill Lynch US High Yield Master II Index	0.4545	0.3654	0.0891
JNK	0.4903	0.4427	0.0476
FHIAX	0.4123	0.3525	0.0598
BHYAX	0.5344	0.3794	0.1550
VWEAX	0.2922	0.3084	–0.0162
PRHYX	0.4923	0.3986	0.0937
FJSIX	0.5989	0.4410	0.1579
FHAIX	0.4901	0.4178	0.0723
FOCIX	0.5653	0.4029	0.1624
DSIAX	0.2214	0.1680	0.0534
HIIFX	0.7051	0.4897	0.2154
SSTHX	0.1006	0.1261	–0.0255
TFCIX	0.7504	0.4429	0.3075

Source: Morningstar for monthly holding period returns [www.morningstar.com], author's own calculations.

measure, of course, cannot tell investors that a particular fund will collapse, but it can reveal relative levels of liquidity risk and changes in liquidity risk over time. The model can direct investors to consider other high yield funds with lower risks. Successful investing is mostly about avoiding costly mistakes; it seems that TFCIX was an investment mistake that could have been avoided.

Finally, let us apply the lagged effects model as in [Asness et al. 2001], to the case of TFCIX. First, I calculated the lagged Betas for the various funds, index, and benchmark using Equation (2) above. Next, I calculated a contemporaneous Beta in each case using the usual CAPM equation, as in Equation (3) above. The results are presented in the Table 3.

First, note that the contemporaneous Beta for the index and the benchmark are both 0.36, and that ten of the twelve funds in the peer group have contemporaneous Beta measures that are similar to the index and benchmark. (The only exceptions are the Wells Fargo (SSTHX, a short term fund) and the Diamond Hill (DSIAX) fund.)

Second, note that the lagged effects model shows some of the funds in the peer group to have little or no latency or non-synchronous price reaction. That is, funds such as SSTHX, DSIAX, FHAIX, VWEAX and FHIAX are likely to have no problems with illiquid securities, stale pricing, or hidden exposure to market risk. On the other hand, TFCIX is shown by the lagged effects model to exhibit the greatest level of latent risk exposure (i.e. an increase in Beta from 0.44 to 0.75), due to what we now know to a large proportion of illiquid and hard-to-price assets in its portfolio.

Third, note that the ordering of liquidity risk by the lagged effects model largely confirms the ordering from the serial correlation model. Of the four funds with the highest level of risk in the lagged effects model, three of them are the three funds with the highest serial correlation in Chart 1 above. The three funds with the lowest liquidity risk as measured by the serial correlation model from Chart 1 above (i.e. JNK, VWEAX, and SSTHX) are also the three funds with the lowest liquidity risk as measured by the lagged effects model.

4. General test of the serial correlation model

My first general test of the serial correlation and lagged effects models is to confirm the intuition that US large-cap stocks are more liquid than US mid-cap stocks, which in turn are more liquid than US small-cap stocks; and similarly that mutual funds that invest in US large-cap equities are, as a group, more liquid than US mid-cap stock funds, which in turn are more liquid than US small-cap stock funds.

I can confirm these results by applying the serial correlation model to the appropriate equity and fund indices. Using the Russell series of US equity indices and applying Equation (1) above, I obtained the following results (see Table 4).

Table 4. Serial correlation betas for major stock indices

January 1980 through December 2015 (432 months)	Represented by	β_{iT} in AR(1) process, Eq. (1)	(*p*-value)
Mega Cap	Russell Top 200 TR Index	.0322	(0.505)
Large Cap	Russell 1000 TR Index	.0644	(0.182)
Mid Cap	Russell Mid Cap TR Index	.1198	(0.013)
Small Cap	Russell 2000 TR Index	.1220	(0.011)

Source: Morningstar for index returns [www.morningstar.com], author's own calculations.

We can see that the serial correlation Beta is statistically insignificant for the Mega Cap and Large Cap stock indices. That is, for the largest market cap stocks, the monthly return in month T is not related to the monthly return in the previous period, month T-1; these stocks trade on a liquid basis, and the return for one month is not dependent on the return in the prior month. For Mid Cap and Small Cap stocks, however, the p-values show that the serial correlation is statistically significant at better than a 98% confidence level, with the smaller stocks having a slightly higher serial correlation. Given the discussion above of the factors described in the literature as giving rise to serial correlation in return series, we can fairly conclude by this liquidity risk measure that liquidity risk increases monotonically as stock market cap declines for stocks arranged in groups by market cap.

Next, I extended the analysis to mutual funds by investment strategy category (see Table 5)

Table 5. Serial correlation betas for mutual fund indices

January 1990 through December 2015 (312 months)	Represented by	Number of Funds in Index (2015):	β_{iT} in AR(1) process, Eq. (1)	(*p*-value)
Large Cap Blend mutual funds	Morningstar US Open End Large Blend Mutual Funds Category Index	1606	.0727	(0.199)
Mid Cap Blend mutual funds	Morningstar US Open End Mid Blend Mutual Funds Category Index	432	.1230	(0.030)
Small Cap Blend mutual funds	Morningstar US Open End Small Blend Mutual Funds Category Index	780	.1248	(0.027)

Source: Morningstar for index data [www.morningstar.com], author's own calculations.

As in the case of stocks categorized by market cap, similarly for mutual funds grouped by market cap strategy category, large cap stock mutual funds exhibit essentially little perceptible liquidity risk as measured by the serial correlation,

while mid cap and small mutual funds exhibit statistically significant levels of serial correlation and hence lower liquidity by this measure.

Next, let us look at the ten categories of mutual funds that are the cause of the SEC's worry about liquidity risks facing the investing public in mutual funds. As mentioned above, these ten categories are the seven Morningstar categories of so-called liquid alternative mutual funds, plus the three other categories that market participants had voiced liquidity concerns about (see Table 6).

Table 6. Serial correlation betas for selected investment strategy categories

January 2008 through December 2015 (96 months)	Represented by	β_{iT} in AR(1) process, Eq. (1)	(p-value)	Ranking by β_{iT}
Market Neutral mutual funds as a group	Morningstar US Open End Market Neutral Category Index	-.1318	(0.199)	7
Long Short Equity mutual funds as a group	Morningstar US Open End Long Short Category Index	.1217	(0.236)	3
Multi-alternative mutual funds as a group	Morningstar US Open End Multi--alternative Category Index	.3113	(.002)	2
Non-traditional Bond mutual funds as a group	Morningstar US Open End Non--traditional Bond Category Index	.5159	(0.000)	1
Bear Market mutual funds as a group	Morningstar US Open End Bear Market Category Index	.0135	(0.895)	6
Managed Futures mutual funds as a group	Morningstar US Open End Managed Futures Category Index	.0636	(0.541)	5
Multi-currency mutual funds as a group	Morningstar US Open End Multi--currency Category Index	.1030	(0.364)	4
High Yield mutual funds as a group	Morningstar US Open End High Yield Category Index	.3253	(0.000)	x
Emerging Markets Debt mutual funds as a group	Morningstar US Open End Emerging Markets Bond Category Index	.1563	(0.039)	x
Emerging Markets Equity mutual funds as a group	Morningstar US Open End Diversified Emerging Markets Category Index	.2178	(0.004)	x

Source: Morningstar for category returns [www.morningstar.com] and author's own calculations.

Of the seven liquid alternative fund categories, two exhibit serial correlation measures that are clearly statistically significant and could indicate liquidity risk. These are the nontraditional bond and multi-alternative categories. Of the other three categories of concern to the SEC (high yield bonds and emerging markets debt and equity funds), all three show serial correlation to be significant at the 95% confidence level or better, indicating the presence of liquidity risk among these funds treated on an aggregate basis as a strategy group.

5. Conclusion

I borrowed the lagged effects and the serial correlation models from the hedge fund literature and applied them in the context of daily-liquidity, SEC-registered, US mutual funds. I found that the models yield useful and consistent measures of liquidity risk. In addition to applying the models to groups of funds aggregated by strategy, I applied the model to specific, individual mutual funds, namely a peer group of high yield mutual funds in the wake of the December 2015 collapse of the Third Avenue Focused Credit Fund. I found that the models performed well with respect to individual funds as tools to identify and measure liquidity risk. In particular, the serial correlation model gave a clear signal as early as January 2015 of higher than normal liquidity risk in the collapsed fund. The serial correlation and the lagged effects models will be useful tools in gauging liquidity risk, as well as in evaluating fund performance at the level of the individual fund. In further studies I will investigate the efficiency, performance, and liquidity aspects of liquid alternative funds.

Significantly, the models can be used across a range of fund types. Other liquidity risk measurement methods rely on securities trading data, fund portfolio holdings data, and fund flow data. In effect, this restricts the use of those other methods to investment areas where high quality data is available, such as US large-cap equity funds. Our two models use fund historical monthly holding period returns which are available for all funds, irrespective of whether fund portfolio holdings data, securities trading data, or fund flow data are available. Therefore these models are especially valuable in the analysis of liquid alternative funds and hedge funds. Additionally, these models could be applied in the context of Poland's domestic funds marketplace. There are about 25 domestic Polish, open-ended, absolute return funds, as distinct from the domestic Polish traditional long-only equity funds. This is a new area for research, with one article on the performance of these funds already published [Perez 2014]. The previous research found the Polish absolute return funds to earn higher positive Alphas than the traditional stock funds. The research in this area could potentially be extended to include an assessment of the Polish funds' liquidity and liquidity risk; on this basis, further research could reassess the risk-reward relationship for Polish domestic funds. Finally, the serial correlation and lagged effects models could be applied to Europe's UCITS funds to contribute to a deeper understanding of the risk-reward trade-off in UCITS funds that invest in less-liquid securities, including UCITS funds in the liquid alternative categories.

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