Three Models of the Liquidity Premium

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Authors

Jamil Baz jamil.baz@pimco.com +44 20 3640 1430	Jamil Baz is a managing director and head of client solutions and analytics at PIMCO.
Lloyd Han lloyd.han@pimco.com +44 20 3640 1501	Lloyd Han is a senior vice president and quantitative research analyst at PIMCO.
Marc-Antoine Loo MarcAntoine.Loo@pimco.com +1 (949) 720-6203	Marc-Antoine Loo is a quantitative research analyst at PIMCO.

Abstract

Despite extensive research, the liquidity premium, defined as the additional return investors demand for holding illiquid assets over their liquid counterparts, remains complex. In this piece, we introduce three distinct yet complementary models to better understand and quantify the liquidity premium. The first model considers it as compensation for foregone opportunities in liquid markets. The second model sees the value of return smoothing in illiquid assets, which can mitigate behavioral biases and potentially lead to a negative premium. The third model views the liquidity premium as the cost of insurance against running out of readily accessible capital. By synthesizing these perspectives, we find a more comprehensive estimate of the liquidity premium at approximately 2% per annum for a typical institutional investor. While the liquidity premium is multifaceted, its quantification is a key input for asset allocation decisions. Our models can help in evaluating the trade-offs associated with investing in illiquid assets, and we encourage investors to consider applying these frameworks to derive a tailored estimate that aligns with their specific investment context.

Keywords: Liquidity premium, illiquid assets, opportunity cost, behavioral biases

The liquidity premium, defined as the excess return of an illiquid asset above its liquid counterpart, is a much-studied topic. Prior research highlights the myriad of costs and benefits that private assets impart to investors, with each paper looking at a different facet of the liquidity premium. In this article, we construct three unique, yet complementary approaches to quantifying the liquidity premium. Our approach does not aim to encompass the existing works. Instead, we look to present three salient components that we combine into an estimate of the liquidity premium with practical implications. Our estimate of the liquidity premium varies with investor skill and the asset allocation, and can help asset allocators evaluate illiquid assets for their portfolios.

In the first approach, an investor allocating capital to private assets foregoes the opportunity of actively trading that capital. Investors will require a premium to compensate them for that missed opportunity. The liquidity premium can thus be viewed as the net present value of foregone alpha – of course assuming that alpha exists at all.

In the second approach, private returns are smoothed, and private assets trade only by appointment on secondary markets. This illiquidity feature shields investors from their "inner demons". Indeed, many investors are known to buy high due to fear of missing out (FOMO) and sell low as they unwind at panic points. The absence of a secondary market is therefore a likely benefit, which we estimate below.

In the third approach, private asset investors incur a so-called liquidity cost from the risk of breaching their liquidity thresholds when risk assets sell off. It turns out that this liquidity cost can be analyzed as the difference between two put options.

By adding the cost of foregone alpha and the liquidity cost and subtracting the benefit of smoothing, we estimate a liquidity premium of a typical institutional investor of around 1.7% per year, representing a more complete picture of pros and cons associated with illiquid assets. We find that the liquidity premium is higher for an investor that is more skilled and has a higher existing allocation to illiquid assets in his portfolio. Our framework helps quantify the extra premium over an alternative liquid asset that investors should demand when considering private investments.

I. The cost of foregone alpha

We begin by analyzing the liquidity premium from the lens of opportunity cost. By allocating to an illiquid asset, investors give up the ability to take advantage of future market opportunities. From this perspective, the liquidity premium can be seen as compensation for foregone alpha.

Amihud and Mendelson (1986), Acharya and Pedersen (2005), and Longstaff (2017) have papers on the liquidity premium which are similar in spirit. These papers measure the cost of foregone alpha as a premium for patience, a risk factor that should command an associated risk premium, and a look-back option to sell an asset at its intra-horizon high. Our approach differs in that it does not require utility functions nor estimates of risk premia. Instead, we model the liquidity premium as an investor's expectation of available alpha in the market.

To formalize our approach, we measure alpha as consisting of two components: (1) normal alpha and (2) jump alpha. Normal alpha is a continuous stream that an investor can earn from exploiting relatively known alpha sources, such as timing, asset selection, and position sizing. Jump alpha refers to extraordinary times of market dislocations that occur infrequently but can result in significant opportunities. The 2008 financial crisis, the COVID-19 recession, and other periods of market stress would correspond to jumps.

We model the continuous alpha stream as a mean-reverting process. This process captures general opportunities available in markets that investors harvest such as premia associated from carry, value, and momentum. For the jump alpha, we use a Poisson process, enabling investors to benefit from a "dry-powder" strategy. This strategy is activated during discontinuous jumps in crisis periods.[1]

Using our specification, we compute the present value of expected alpha over an investment horizon then rescale this quantity into an illiquidity discount. The higher the discount, the higher the required return of the illiquid asset such that the illiquid asset earns both the liquid-equivalent return and the foregone alpha.

Investors vary in their confidence and ability to generate alpha. A skillful investor such as Warren Buffett would have a higher expectation of available alpha in the market and demand a larger liquidity premium than a less skilled investor. Additionally, investors may use different specifications for the alpha process that depend on their subjective views. We provide a representative quantitative example here to estimate one set of reasonable parameters using our proposed specifications. Investors can freely apply the framework and estimate their own liquidity discounts.

To model the continuous alpha process, we create a simple representative long-short trading strategy on a wide selection of equity index futures based on valuations. For the continuous jump process, we look at buying and holding dislocated assets during market drawdowns.[2]

To illustrate our model predictions for particularly skilled investors, we use the example of Warren Buffett, who has shown a consistent ability to add alpha throughout his long and storied career. Frazzini, Kabiller, and Pedersen (2018) estimated Buffett's information ratio from 1976 to 2017 to be an impressive 0.79. We scale this value to a constant 10% volatility strategy, yielding an alpha for Buffett of 7.9% and calibrate the continuous alpha process to match Buffett's historical

[1] See Appendix for the formal mathematical definitions of the processes used to model alpha.
[2] See Appendix for details on calibration.

performance. Using our calibrated values, we compute the annualized illiquidity discount for various horizons in the table below.

Exhibit 1: Illiquidity discounts for various horizons

Total and annual illiquidity discounts versus the investment horizon

		Investment horizon (in years)									
	Skill Level	1	2	3	4	5	6	7	8	9	10
Total discounts	Average	1.9%	3.8%	5.5%	7.1%	8.6%	10.0%	11.3%	12.6%	13.8%	15.0%
	Buffett	7.2%	13.3%	18.6%	23.1%	27.0%	30.5%	33.6%	36.3%	38.8%	41.0%
Annual discounts	Average	1.9%	1.9%	1.9%	1.8%	1.8%	1.7%	1.7%	1.7%	1.6%	1.6%
	Buffett	7.2%	6.9%	6.6%	6.4%	6.1%	5.9%	5.7%	5.5%	5.3%	5.1%

Source: PIMCO and Bloomberg as of 30 September 2020. **For illustrative purposes only.**

We find that for a horizon of 10 years, which is close to the time it takes a typical private equity fund to finish distributing its capital, representative investors should expect a liquidity premium of 1.6% to compensate them for the foregone alpha. For a Buffett type investor, the premium increases to 5.1%. Our results imply that an illiquid allocation should generate a liquidity premium of 1.6%-5.1% to compensate investors for foregone alpha.

Our quantitative illustration gives a range for the liquidity premium based on the alpha that an investor could have realized historically. This framework is open to discussion. For example, proponents of efficient markets view alpha as zero on average. Even then, we take a moment to note that asset prices are based on the beliefs of the marginal investor. Thus, what matters is what alpha the investor believes he or she can achieve, whether or not the belief is justified. This introduces an interesting behavioral angle to our model in which the market-clearing illiquidity discount should be considered not on the basis of what is realistic but rather on the basis of investors' views of their own abilities.

In this context, there is evidence to suggest that individuals may overestimate their mental aptitude when it comes to assessing their own cognitive abilities. Several studies have found that men in particular tend to overestimate their IQs, with findings of overestimation ranging between 2.5 and 7.8 IQ points (Reilly and Mulhern 1995).7 If, indeed, this overconfidence extends to the pricing of financial assets, the illiquidity discount in particular, this implies that illiquidity discounts may be higher than necessary, reflecting biased self-perceptions of alpha skill. Interestingly, translating IQ overestimation into the equivalent of a Sharpe ratio, dividing by the IQ standard deviation of 15, implies a Sharpe ratio of between 0.17 and 0.52. These values lead to results not dissimilar from our quantitative illustration.

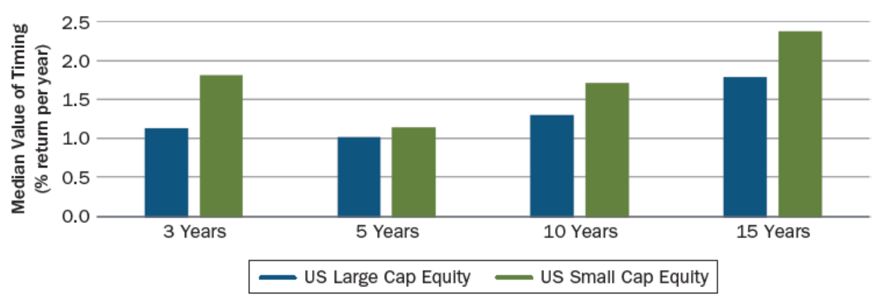
II. The benefit of smoothing

In our second approach, we look at the liquidity premium through the lens of smoothing. Asness (2019), Phalippou (2020), and Baz et al. (2022) show that smoothing of returns in privates, while artificial, can have real benefits. Investors are much less likely to observe drawdowns in illiquid assets, and illiquidity means investors are less likely to fall victim to behavioral biases through excessive trading. These benefits imply a negative liquidity premium, and illiquid assets under this perspective should have a lower return than their liquid counterparts.

To quantify this perspective we try to estimate the potential behavioral pitfalls associated with excess trading. Barber and Odean (2011) document multiple suboptimal behaviors of investors, such loss aversion, attention allocation, and diversification strategies. Furthermore, investors tend to sell assets when markets are falling, even though expected returns are often highest precisely when prices are lowest. By locking up their money in private assets, limited partners (LPs) may reduce the loss in performance due to behavioral biases.

Using data from Morningstar, we attempt to quantify just how much the average investor may lose by trying to trade in and out of markets. In Exhibit 2, we show the median annualized difference between the total return and the Morningstar investor return for funds in the US large-cap equity and US small-cap equity categories. The Morningstar investor return is a dollar-weighted return that takes into account the cash inflows and outflows of the funds in each category.

Exhibit 2: Median value of timing for US large-cap and US small-cap equity



Source: Morningstar as of 31 December 2023. **For illustrative purposes only.**

Interestingly, for all horizons the investor return is lower than the total return of the funds, meaning that the average investor generates negative returns by varying their exposure over time. For the 10-year horizon, roughly consistent with the life of buyout funds, we see there is a 1.7 percentage point (pp) per year tailwind from not adjusting the allocation to the US small-cap equity category. If we take small caps as representative of buyouts, we find investing in private equity may deliver

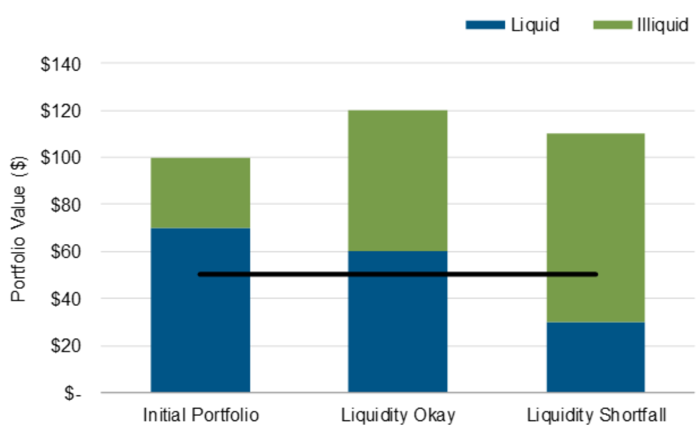
1.7 pps a year just by averting behavioral biases. Thus, we find there is approximately a -1.7% liquidity premium for illiquid assets that benefit investors through smoothing.

III. The cost of illiquidity risk

By cost of illiquidity risk, we refer to compensation that investors should demand for the risk of a shortfall in liquid assets required for spending. Illiquid assets that lock investors into a position for long periods tend to generate higher returns than assets that are freely tradeable. However, adding illiquid assets increases the likelihood that the portfolio runs out of accessible money. From the lens of illiquidity risk, private assets should have a higher return to compensate investors for the risk of insolvency.

To model illiquidity risk, we assume that an investor requires liquid assets, denoted L_t, to remain above a certain threshold $\bar{L}$ at the end of their investment horizon T.

Exhibit 3: Illustration of an investor's liquidity requirement



Source: PIMCO as of 31 December 2023. **For illustrative purposes only.**

We model the cost of illiquidity risk as the price of an insurance contract that hedges the portfolio against any shortfall in liquid portfolio value. The payoff of such an insurance contract has terminal value $max(0, \bar{L} - L_t)$ which is tantamount to a put option on L_t with strike $\bar{L}$.

However, we note that even a portfolio that consists fully of liquid assets has a probability of a shortfall. Thus, we define the cost of illiquidity risk as the additional cost of insurance compared to a fully liquid portfolio. More formally we define

$$Cost\ of\ Iliquidity\ Risk = Put(Portfolio, \bar{L}) - Put(Fully\ Liquid\ Portfolio, \bar{L})$$

where we use the notation $Put(Underlying, Strike)$ to denote the price of a put.

To quantify the cost of illiquidity risk, we make the simplifying assumptions that there are no capital calls or distributions from the illiquid asset.[3] In this case, we find the cost of insurance depends only on the evolution of the liquid portfolio over the investment horizon. As a result, we can price illiquidity risk as the price difference between two European put options on the liquid portfolio using Black-Scholes.[4]

To make our framework concrete, we apply this to the average U.S. public plan portfolio.[5] For illustrative values we compute the cost of illiquidity insurance for different values of $\bar{L}$ (shown as a percentage of total initial portfolio value) and different starting allocation to illiquid assets.

Exhibit 4: Black-Scholes cost of Liquidity insurance

Input parameters	
Risk free rate	3.51%
Dividend yield	1.4%
Horizon	5 years
Liquid portfolio volatility	10%
Implied/Realized premium	1.2

Cost of liquidity insurance (% annualized)

		Starting illiquids					
		10%	20%	25%	30%	40%	50%
Liquidity threshold	**40%**	0.00%	0.01%	0.01%	0.02%	0.09%	0.36%
	50%	0.01%	0.05%	0.09%	0.15%	0.46%	1.33%
	60%	0.05%	0.19%	0.32%	0.52%	1.30%	
	65%	0.10%	0.32%	0.53%	0.83%		
	70%	0.16%	0.50%	0.79%	1.21%		
	75%	0.24%	0.73%	1.12%			
	80%	0.35%	0.99%				

Source: PIMCO as of 31 December 2023. **For illustrative purposes only.**

[3] See Baz et al. (2024) for a generalization where we incorporate capital calls and distributions.

[4] By our definition of illiquidity, an investor requires a certain amount of assets to be liquid at the end of the investment horizon.

[5] Average US Public Plan Portfolio is based on RVK Average Public Plan asset allocation survey. This portfolio is composed of 25% illiquid assets and 65% public assets. Refer to Appendix for further information on the Average US Public Plan Portfolio.

In the table above, we see that the cost of illiquidity insurance is an increasing convex function of the starting percentage of illiquid assets and of the required liquidity. For a liquidity threshold of 65% and 25% starting illiquid asset in the portfolio, we find that the cost of liquidity insurance is 0.53% of the total portfolio's starting value per year.

Under this simplified framework, we can also compute the breakeven illiquidity premium in order for an illiquid investment have a positive return impact net of the cost of illiquidity on the portfolio. We compute this by dividing the cost of liquidity insurance by the percentage of illiquids in the portfolio. We show the results in Exhibit 5 below.

Exhibit 5: Breakeven illiquidity premium

Breakeven illiquidity premium (% annualized)

		Starting illiquids					
		10%	**20%**	**25%**	**30%**	**40%**	**50%**
Liquidity threshold	**40%**	0.01%	0.03%	0.05%	0.08%	0.23%	0.72%
	50%	0.12%	0.23%	0.34%	0.51%	1.16%	2.66%
	60%	0.55%	0.96%	1.29%	1.75%	3.25%	
	65%	0.98%	1.62%	2.11%	2.76%		
	70%	1.61%	2.51%	3.17%	4.02%		
	75%	2.43%	3.63%	4.47%			
	80%	3.45%	4.96%				

Source: PIMCO as of 31 December 2023. **For illustrative purposes only.**

For a liquidity threshold of 65% and 25% starting illiquid assets in the portfolio, we find the liquidity premium from the cost of illiquidity is 2.1% per year.

IV. Putting the models together

Combining three salient flavors, we find that the total liquidity premium for a typical institutional investor is approximately 2% per year. We calculate this quantity by taking the sum of 1.6% from the cost of alpha, -1.7% from the benefit of smoothing, and 2.1% from the cost of illiquidity risk. We find it serendipitous that the three facets we analyzed suggest similar magnitudes, but we take comfort from the fact that our estimate lines up well with other results in the literature.[6]

[6] See Ang et al. (2014) and Ilmanen et al. (2020) which find estimates for the liquidity premium around 2%.

Using PIMCO's latest capital market assumptions[7], we find the liquid portion of the average U.S. public plan portfolio has an expected return of 5.9% per year. Thus, investors should require illiquid strategies to have an expected return of at least 8.0% to consider illiquid investments. This hurdle rate will vary depending on investor skill and portfolio composition, as an investor that is more skilled and already has a high allocation to private strategies in their portfolio will command a higher liquidity premium.

While the trifecta of models we present can serve as a helpful guide for asset allocators, we acknowledge that there are aspects that the model fails to capture. For example, our analysis did not assume the existence of a gray market or secondary sales. Gauron et al. (2023) find that private market secondaries trade at a discount of 15% to 25% with the discount potentially increasing to 40% during crisis periods. Furthermore, our model does not capture capital calls and capital distributions.[8] These are important details that require more sophisticated analysis, and we leave the incorporation of these aspects for future work.

Conclusion

The liquidity premium takes on many shapes and forms. Some facets suggest the premium should be positive given lack of tradability while others suggest the premium should be negative given the benefits of not marking assets to market. In this piece, we construct three models that take different perspectives on the liquidity premium. By combining the different flavors together, we construct a more holistic measure of the pros and cons of investing in illiquid assets that can serve as a guide for asset allocators. While the precise estimate will vary depending on expectations and constraints, we find that a liquidity premium of 2% per annum to be a reasonable estimate for the typical institutional investor. We encourage investors to apply the three frameworks outlined above to get a bespoke estimate fit to their specific investment circumstances.

[7] See Browne et al. (2023) for more information on PIMCO's capital market assumptions as of August 2023.
[8] See Baz et al. (2024) to see how the cost of illiquidity risk can be extended to incorporate private asset cash flows.

References

Amihud, Y. and H. Mendelson, 1986, “Asset Pricing and the Bid-Asked Spread”, *Journal of Financial Economics 17, 223-249*

Ang, Andrew. 2014. “Estimating Private Equity Returns from Limited Partner Cash Flows.” *Columbia Business School Research Paper.* No. 13-83.

Antti Ilmanen. 2020. “The Impact of Smoothness on Private Equity Expected Returns” *The Journal of Investing. DOI: 10.3905/joi.2020.1.151*

Asness, Cliff. 2019. “The Illiquidity Discount?” *AQR Capital management*

Barber, Brad M. and Odean, Terrance. 2011. “The Behavior of Individual Investors”. *Available at SSRN: https://ssrn.com/abstract=1872211 or http://dx.doi.org/10.2139/ssrn.1872211*

Baz Jamil, Davis Josh, Han Lloyd and Stracke Christian. 2022. “The Value of Smoothing”. *The Journal of Portfolio Management Private Markets 2022, 48 (9) 73 – 85*

Jamil Baz, Steve Sapra, Christian Stracke, Wentao Zhao. 2021. “Valuing a Lost Opportunity: An Alternative Perspective on the Illiquidity Discount”. *The Journal of Portfolio Management. DOI: 10.3905/jpm.2020.1.197*

Browne, Erin. Helen Guo, and Andrew Nowobilski. 2023. “PIMCO’s Capital Market Assumptions – August 2023.” *PIMCO.*

Frazzini, Andrea and Kabiller, David and Pedersen, Lasse Heje. 2019. “Buffett's Alpha”. *Financial Analysts Journal, 2018, 74 (4): 35-55*

Han, Lloyd S. and Ramirez, German. 2024. “A Practitioner's Guide to Managing a Privates Program”. *Available at SSRN: https://ssrn.com/abstract=4685467 or http://dx.doi.org/10.2139/ssrn.4685467*

Longstaff Francis, Kurt F. Lewis, Francis A. Longstaff & Lubomir Petrasek. 2017. “Asset Mispricing”. *Working paper*

Phalippou, Ludovic. 2020. “An Inconvenient Fact: Private Equity Returns & The Billionaire Factory”. *University of Oxford, Said Business School, Working Paper*

Reilly, J., & Mulhern, G. 1995. “Gender differences in self-estimated IQ: The need for care in interpreting group data”. *Personality and Individual Differences, 18(2), 189–192*

Suzanne Gauron, Harold Hope, Gabriel Mollerberg and Thom Spoto. 2023 “Private Secondaries Markets: To Liquidity, and Beyond.” *Goldman Sachs Asset Management*

Viral V.Acharya and Lasse Heje Pedersen. 2004. “Asset Pricing with Liquidity Risk”. *NBER Working Paper No. w10814, Available at SSRN: https://ssrn.com/abstract=601116*

Appendix

A. *Details on the cost of foregone alpha*

To model the continuous alpha stream, we use an Ornstein-Uhlenbeck process.

$$d\alpha_t = k(\mu - \alpha_t)dt + \sigma dW_t$$

$k > 0$ denotes the speed of mean-reversion, μ the long-term mean of available alpha in the market, and σ the volatility of alpha. This smooth mean-reverting process captures general opportunities available in markets that investors harvest such as premia associated from carry, value, and momentum.

For the jump alpha, we use a Poisson counting process. For a Poisson process q_t with intensity λ, the probability of an instantaneous jump is $P(dq_t \geq 1) = \lambda dt$. The expected return on the dry powder is

$$E(Jdq_t) = \lambda Jdt$$

where J is the alpha an investor earns during a market dislocations. We can then solve for the expected alpha over a horizon from time 0 to time T.

$$V = \frac{\mu}{r}(1 - e^{-rT}) + \frac{\lambda J}{r}(1 - e^{-rT}) + \frac{\alpha_0 - \mu}{r + k}\left(1 - e^{-(r+k)T}\right)$$

Where α_0 represents the alpha state at the beginning of the period and r is the risk free rate. We then convert the present value of alpha into an illiquidity discount, Δ, using the following formula

$$\Delta = \frac{V}{1 + V}$$

To model the continuous alpha process, we take 35 equity index futures and rank them by dividend yield. We then create monthly portfolios that go long the top three indices with the highest dividend yield and short the bottom three indices with the lowest dividend yield. We size each position based on the inverse of its 36 month realized historical volatility and assume a 5bp transaction cost each way. To compute the alpha of the long short portfolio, we use a 24-month rolling regression of the strategy return on the excess return of the MSCI ACWI index. We then use the time series of alpha to estimate the parameters of the Ornstein-Uhlenbeck process.

For the continuous jump process, we look at the S&P500 index during periods where the peak-to-trough drawdown exceeded the annualized volatility inferred from a rolling 36-month window. When such an event happens, we look at a universe of 11 equity, fixed-income, and commodity futures and buy those that have experienced peak-to-trough drawdowns in excess of two standard deviations. We hold each investment for 24-months, at which point it is automatically sold. The thresholds used here are meant to be illustrative of a dry powder strategy and not calibrated values.

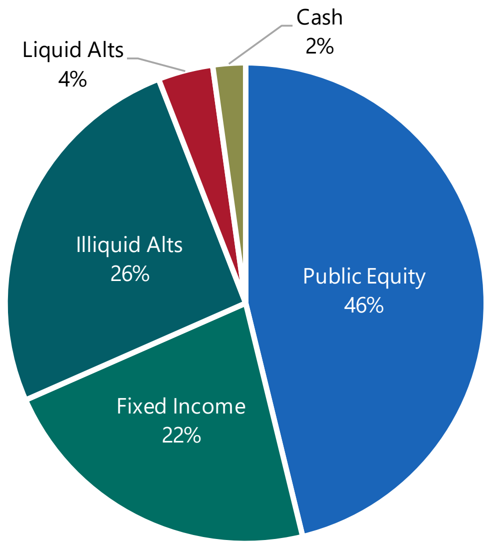
We find the following parameters as a result of the estimation.

Continuous Process	μ	0.010
	k	1.050
	σ	0.042
Jump Process	J	0.05
	λ	0.200

We assume the current level of alpha α_0 is at its long-run level of 1% and use the market-prevailing interest rate for r.

B. *Details on the cost of illiquidity risk*

1. **Portfolio Statistics:** We show the statistics on the average U.S. public plan portfolio in the table below.



Portfolio Statistics	
Return	6.60%
Volatility	12.1%
Dividend Yield	1.1%
Sharpe Ratio	0.26
% of Illiquid Assets	26%

Source: RVK and PIMCO as of 31 December 2023. **For illustrative purposes only. Figure is not indicative of the past or future results of any specific product or strategy. There is no assurance that the stated results will be achieved.** Avg. US Public Plan Portfolio based on RVK Average Public Plan asset allocation survey. Return estimates are an average annual return over a 5-year horizon. Proxy returns are provided gross of fees. Returns would be lower if fees were applied. It is not possible to directly invest in an unmanaged index. Sharpe ratio is calculated as estimated return minus the return estimate for cash, 3.51%, divided by estimated total volatility. Refer to Additional Important Information for further information on estimated returns and estimated volatility.

Average U.S. public pension plan portfolio assumptions

Asset Class	Proxy	Estimated Return[1]	Estimated Volatility[2]	Avg. US Public Plan Portfolio
Public Equity	S&P 500 Index	6.5%	15.2%	17.5%
	MSCI ACWI Index	6.5%	15.3%	4.2%
	MSCI EAFE Index	6.2%	16.4%	13.8%
	MSCI Emerging Markets Index	7.4%	18.8%	3.2%
	Russell 1000 Growth Index	6.5%	17.3%	1.7%
	Russell 1000 Value Index	6.5%	14.6%	2.0%
	Russell 2000 Growth Index	6.5%	20.4%	1.0%
	Russell 2000 Index	6.5%	21.0%	1.7%
	Russell 2000 Value Index	6.5%	22.0%	1.2%
Fixed Income	BBG Global Agg Index [USD-H]	4.7%	4.0%	0.9%
	BBG Global Agg ex-US Index [USD-H]	4.7%	3.6%	0.6%
	BBG US Agg Index	4.6%	4.9%	20.7%
Liquid Alts	HFRI Fund Weighted Composite Index	7.1%	8.1%	3.0%
	HFRI Distressed/Restructuring Index	8.0%	10.6%	0.7%
Illiquid Alts	Private Equity Model*	9.4%	27.5%	9.7%
	Venture Capital Model*	5.9%	31.9%	1.6%
	Private Corporate Credit Model*	8.2%	12.5%	2.4%
	Private Value-Add Real Estate Model*	8.6%	16.8%	12.0%
Cash	ICE BofAML 3M T-Bill Index	3.5%	0.2%	2.2%
	Total			**100.0%**
	Sum of Privates			**25.7%**

Source: RVK and PIMCO as of 31 December 2023. **For illustrative purposes only. Figure is not indicative of the past or future results of any specific product or strategy. There is no assurance that the stated results will be achieved.**

[1] Return estimates are an average annual return over a 5-year horizon. Please refer to Additional Important Information for further information on estimated returns.

[2] See Additional Important Information for further information regarding volatility estimates.

*Model risk factor exposures are based on analysis of historical index data, third party academic research and/or qualitative inputs from senior PIMCO investment professionals. Models are provided as a proxy for asset classes where a market index is not available and are not intended or generally made available for investment purposes. Avg. US Public Plan Portfolio based on RVK Average Public Plan asset allocation survey. Proxy returns are provided gross of fees. Returns would be lower if fees were applied. It is not possible to directly invest in an unmanaged index.

Based on PIMCO's proprietary risk system, we estimate the liquid portion of the portfolio has a volatility of around 10% with a dividend yield of 1.4%. We also assume implied volatility trades at a 20% premium to realized.

2. Black-Scholes cost of Liquidity insurance (American Put): Instead of using European put options, we price illiquidity risk as the price difference between two American put options on the liquid portfolio using Black-Scholes. Please, find the results in the tables below.

Input parameters	
Risk free rate	3.51%
Dividend yield	1.4%
Horizon	5 years
Liquid portfolio volatility	10%
Implied/Realized premium	1.2

Cost of liquidity insurance (% annualized)

		Starting illiquids					
		10%	20%	25%	30%	40%	50%
Liquidity threshold	40%	0.00%	0.01%	0.01%	0.02%	0.10%	0.40%
	50%	0.01%	0.05%	0.09%	0.17%	0.53%	1.59%
	60%	0.06%	0.22%	0.37%	0.60%	1.56%	
	65%	0.11%	0.37%	0.61%	0.98%		
	70%	0.18%	0.59%	0.94%	1.46%		
	75%	0.28%	0.87%	1.36%			
	80%	0.41%	1.21%				

Breakeven illiquidity premium (% annualized)

		Starting illiquids					
		10%	20%	25%	30%	40%	50%
Liquidity threshold	40%	0.01%	0.03%	0.05%	0.08%	0.25%	0.81%
	50%	0.13%	0.26%	0.38%	0.56%	1.32%	3.19%
	60%	0.61%	1.08%	1.46%	2.01%	3.91%	
	65%	1.11%	1.85%	2.44%	3.25%		
	70%	1.84%	2.94%	3.77%	4.86%		
	75%	2.83%	4.34%	5.44%			
	80%	4.11%	6.07%				

Source: PIMCO as of 31 December 2023**. For illustrative purposes only.**

For a liquidity threshold of 65% and a 25% starting illiquid assets in the portfolio, we find that the cost of liquidity insurance using an American put is 0.61% of the total portfolio starting value per year. Similarly, the liquidity premium from the cost of illiquidity is 2.44% per year.

Additional Important Information

This article includes hypothetical illustrations. Hypothetical illustrations have many inherent limitations, some of which are described below. No representation is being made that any account will or is likely to achieve results similar to those shown. In fact there are frequently sharp differences between hypothetical results and actual results subsequently achieved by any particular trading program. One of the limitations of hypothetical results is that they are generally prepared with the benefit of hindsight. In additional, hypothetical scenarios do not involve financial risk, and no hypothetical illustration can completely account for the impact of financial risk in actual trading. For example, the ability to withstand losses or to adhere to a particular trading program in spite of trading losses are material points which can also adversely affect actual trading results. There are numerous other factors related to the markets in general or to the implementation if any specific trading program which cannot be fully accounted for in the preparation of a hypothetical illustration and all of which can adversely affect actual results.

Estimated returns, for indices and asset class models are calculated by identifying the risk factors of the index or model, and then multiplying each risk factor by an estimated return. PIMCO uses a proprietary system that automatically identifies the applicable risk factors of the index or model (e.g., duration risk), based on its underlying securities. Each risk factor is then assigned an estimated return – or “risk factor premium” – which is calculated using historical data, valuation metrics and qualitative input provided by PIMCO’s senior investment professionals.

Past performance is not a guarantee or a reliable indicator of future results.

Estimated volatility employs a block bootstrap methodology to calculate volatilities. We start by computing historical factor returns that underlie each asset class proxy from January 1997 through the present date. We then draw a set of 12 monthly returns within the dataset to come up with an annual return number. This process is repeated 25,000 times to have a return series with 25,000 annualized returns. The standard deviation of these annual returns is used to model the volatility for each factor. We then use the same return series for each factor to compute covariance between factors. Finally, volatility of each asset class proxy is calculated as the sum of variances and covariance of factors that underlie that particular proxy. For each asset class, index, or strategy proxy, we will look at either a point in time estimate or historical average of factor exposures in order to determine the total volatility. Please contact your PIMCO representative for more details on how specific proxy factor exposures are estimated.

The portfolio analysis is based on indices and models. No representation is being made that the structure of the average portfolio or any account will remain the same or that similar returns will be achieved. The analysis may not be attained and should not be construed as the only possibilities that exist. Real results will vary and are subject to change with market conditions. Different weightings in the asset allocation illustration will produce different results. Actual results will vary and are subject to change with market conditions. There is no guarantee that results will be achieved. No fees or expenses were included in the estimated results and distribution. The scenarios assume a set of assumptions that may, individually or collectively, not develop over time. The sample analysis reflected in this information is based upon data at time of analysis. Forecasts, estimates, and certain information contained herein are based upon proprietary research and should not be considered as investment advice or a recommendation of any particular security, strategy or investment product.

PIMCO routinely reviews, modifies, and adds risk factors to its proprietary models. Due to the dynamic nature of factors affecting markets, there is no guarantee that simulations will capture all relevant risk factors or that the implementation of any resulting solutions will protect against loss. All investments contain risk and may lose value. Simulated risk analysis contains inherent limitations and is generally prepared with the benefit of hindsight. Realized losses may be larger than predicted by a given model due to additional factors that cannot be accurately forecasted or incorporated into a model based on historical or assumed data.

The portfolio structure is a representation of a sample portfolio and no guarantee is being made that the structure of the portfolio will remain the same or that similar returns will be achieved.

All investments contain risk and may lose value. Alternatives involve a high degree of risk and prospective investors are advised that these strategies are appropriate only for persons of adequate financial means who have no need for liquidity with respect to their investment and who can bear the economic risk, including the possible complete loss, of their investment.

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