



Applications of derivatives for portfolio risk management

Vineer Bhansali¹ · Frank J. Fabozzi² · Robert Harlow³ · Adam Kobor⁴ · Joseph Niehaus⁵ · Christopher Small⁶ · Andrew Weisman⁶

Revised: 29 July 2024 / Accepted: 30 July 2024
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Abstract

In this article, five in-depth illustrations of practical applications of various derivatives for risk control for asset management are provided. The illustrations are presented using stock index futures, interest-rate derivatives (Treasury futures and interest rate swaps), options, and equity swaps. The cases presented bridge the gap between theoretical finance and practical application, making it invaluable for those involved in risk management for portfolio managers.

Keywords Derivatives · Hedging · Equity swaps · Tail risk hedging · Interest-rate swaps · Duration

Introduction

In this article, we present the following applications of derivatives for portfolio risk management:

- The use of stock index futures and put options to hedge an equity portfolio.
- The utilization of U.S. Treasury futures to modify the interest rate risk associated with a bond portfolio.
- Controlling tail risk which involves rare but impactful investment outcomes, and demonstrates how options can be employed to hedge against this risk.
- The use of equity swaps in active equity portfolio management.
- How the treasurer of a credit union can use interest rate swaps to manage the interest rate risk of a consumer mortgage portfolio.

Hedging with stock index futures and put options

An equity portfolio manager is bullish on all the individual names included in the portfolio shown in Table 1¹, which were determined through bottoms up fundamental research. However, many of the names in the portfolio are high beta, and despite establishing a 5% allocation to cash, the portfolio beta relative to the benchmark, the S&P 500 index, is still 1.1525. Since the portfolio manager does not have a view on the broader market and being uncomfortable being essentially long 15% versus the benchmark, a decision is made to hedge the excess market exposure. Two approaches are being considered by the portfolio manager for hedging:

Futures approach Using the existing cash allocation as collateral for the futures position, sell index futures.

Options approach With a portion of the existing excess cash, buying a 20-delta index put option.

In both cases, the portfolio manager's goal is to reduce exposure to the benchmark without changing the cash market positions. As of February 28, 2020, the S&P 500 index was valued at \$2954.22, a March expiry e-mini future contract on the S&P500 was trading at \$2951, and a 20-delta put with an expiration identical to the March futures contract was trading at \$48.50 and had a strike price of \$2660.

¹ The hypothetical portfolio used in this mini-case is based on the top 50 names of a T. Rowe Price portfolio as of February 28, 2020, renormalized to have a market value of \$150 MN. Additionally, a 5% cash allocation was added to facilitate the illustration. Betas were estimated using historical data between 2016 and February 28, 2020 using historical returns. Futures prices come from Bloomberg and option pricing is from OptionMetrics.

✉ Frank J. Fabozzi
ffabozz1@jhu.edu

¹ LongTail Alpha LLC, Newport Beach, CA, USA
² Carey Business School, Johns Hopkins University, Baltimore, MD, USA
³ T. Rowe Price Group, Inc., and T. Rowe Price Associates, Inc, Baltimore, USA
⁴ New York University Investments Office, New York, NY, USA
⁵ Jefferies | Credit Union Financial Services (CUFS) Group, New York, NY, USA
⁶ Windham Capital Management, Boston, MA, USA



Table 1 Hypothetical Portfolio for Illustration

Name	Ticker	Beta	Weight (%)	ket value (\$)
Vmware Inc-Class A	VMW	1.2498	0.4132	619,871.74
Advanced Micro Devices	AMD	2.0932	0.4219	632,884.71
Northrop Grumman Corp	NOC	0.6888	0.4244	636,629.72
Marsh & McLennan Cos	MMC	0.8124	0.4248	637,262.16
Fleetcor Technologies Inc	FLT	1.1494	0.4363	654,479.73
Hilton Worldwide Holdings Inc	HLT	1.0788	0.4761	714,169.36
Td Ameritrade Holding Corp	AMTD	1.2827	0.4799	719,794.62
Morgan Stanley	MS	1.4860	0.5116	767,366.38
Applied Materials Inc	AMAT	1.6340	0.5468	820,143.18
Lululemon Athletica Inc	LULU	1.0308	0.5777	866,617.03
Nike Inc -Cl B	NKE	1.0028	0.5840	875,938.36
Intercontinental Exchange Inc	ICE	0.6993	0.5873	881,013.40
Hca Healthcare Inc	HCA	0.9182	0.6395	959,274.51
Costar Group Inc	CSGP	1.0378	0.6602	990,230.52
S&P Global Inc	SPGI	1.1278	0.7052	1,057,745.82
Roper Technologies Inc	ROP	1.0107	0.7654	1,148,066.31
Centene Corp	CNC	1.1444	0.8032	1,204,819.51
Elevance Health Inc	ELV	0.9379	0.8198	1,229,760.83
Splunk Inc	SPLK	1.5877	0.9392	1,408,831.56
Nvidia Corp	NVDA	1.8580	0.9895	1,484,178.22
Ross Stores Inc	ROST	0.9173	1.0946	1,641,874.12
Willis Towers Watson Plc	WTW	0.8551	1.0955	1,643,183.84
Becton Dickinson And Co	BDX	0.8866	1.1209	1,681,289.97
Thermo Fisher Scientific Inc	TMO	1.1141	1.2231	1,834,712.23
Workday Inc	WDAY	1.4932	1.2717	1,907,522.19
Booking Holdings Inc	BKNG	1.1201	1.2810	1,921,569.00
Danaher Corp	DHR	0.9331	1.3365	2,004,772.42
Dollar General Corp	DG	0.7246	1.3451	2,017,631.49
Alphabet Inc Cl A	GOOGL	1.2174	1.4674	2,201,043.39
Intuitive Surgical Inc	ISRG	1.2110	1.6075	2,411,221.12
Fiserv Inc	FI	0.9226	1.7371	2,605,583.68
Stryker Corp	SYK	0.8972	1.8979	2,846,873.17
Paypal Holdings Inc	PYPL	1.2994	1.9103	2,865,413.66
Vertex Pharmaceuticals Inc	VRTX	1.3356	1.9832	2,974,863.08
Boeing Co/The	BA	1.1888	1.9906	2,985,855.50
Fidelity National Info Serv	FIS	0.9044	2.0030	3,004,561.13
Cigna Group/The	CI	0.9262	2.0221	3,033,125.89
UnitedHealth Group Inc	UNH	0.9231	2.0579	3,086,793.02
Intuit Inc	INTU	1.1724	2.2917	3,437,607.62
Global Payments Inc	GPN	1.2311	2.3267	3,490,114.25
Salesforce Inc	CRM	1.3530	2.3625	3,543,766.71
Netflix Inc	NFLX	1.5280	2.4949	3,742,282.32
Servicenow Inc	NOW	1.5159	2.6447	3,966,995.67
Apple Inc	AAPL	1.2968	3.4731	5,209,703.56
Mastercard Inc - A	MA	1.2873	3.7525	5,628,709.91
Visa Inc-Class A Shares	V	1.1872	4.3180	6,476,927.37
Microsoft Corp	MSFT	1.3408	6.1092	9,163,866.13
Alphabet Inc Cl C	GOOG	1.2213	6.5689	9,853,284.80
Meta Platforms Inc-Class A	META	1.2136	7.2778	10,916,684.00
Amazon.com Inc	AMZN	1.3452	10.728%	16,093,091.12
Cash USD		0.0000	5.0000	7,500,000.00
Total		1.1525	100.0000	150,000,000.00

The hypothetical portfolio used in this mini-case is based on the top 50 names of a T. Rowe Price portfolio as of February 28, 2020, renormalized to have a market value of \$150 MN. Additionally, a 5% cash allocation was added to facilitate the illustration. Betas were estimated using historical data between 2016 and February 28, 2020 using historical returns. Futures prices come from Bloomberg and option pricing is from OptionMetrics



E-mini futures contracts on the S&P 500 have a multiplier of 50. Therefore, to size the correct number of futures to sell (denoted by N_{futures}), the portfolio manager solves the following equation:

$$N_{\text{futures}} = \frac{\text{Beta target} - \text{Current portfolio beta}}{\text{Futures price} \times 50} \times \text{Portfolio market value}$$

In our illustration we have

$$N_{\text{futures}} = \frac{1.0000 - 1.1525}{\$2951 \times 50} \times \$150,000,000 = -155 \text{ contracts}$$

The negative sign means that the futures should be shorted. Note that because futures contracts do not have a beta of exactly 1, it is appropriate to use the futures price in the denominator. Additionally, the futures contract requires no initial cash outlay, so the portfolio manager's cash position is unchanged at the time the hedge is put on.

Next, the portfolio manager evaluates the put option approach. Options on the S&P 500 have a contract multiplier of 100. The following equation is solved by the portfolio manager to determine the number of put options to purchase (N_{puts}):

$$N_{\text{puts}} = \frac{\text{Beta target} - \text{Current portfolio beta}}{\text{Option delta} \times 100 \times \text{Underlying index value}} \times \text{Portfolio market value}$$

The option delta in our illustration is -0.20 . Substituting this value and the other values for our illustration gives:

$$N_{\text{puts}} = \frac{1.0000 - 1.1525}{-0.20 \times 100 \times 2954.22} \times \$150,000,000 = 387 \text{ contracts}$$

Note that the cash outlay to purchase these contracts is \$1.9 million ($387 \times \48.50×100), which is easily covered by the \$7.5 million cash position.

Now, which approach is better? The answer is, "it depends." Both approaches reduce the effective equity exposure by the same amount at the onset of the trade. However, the futures approach is only exposed to one risk factor (the underlying) and the options approach is exposed to more risk factors (the underlying and the volatility of the underlying). As it turns out, February 28, 2020 was on the eve of one of the most severe sell-offs in stock market history due to the rapid global spread of the Covid-19 virus. Both these contracts expired on March 20, 2020, when the settlement price on the S&P500 was \$2437.98.

Let's compare the profit and loss (P&L) for each approach:

- *Futures Approach:* $-155 \times (2437.98 - 2951) \times 50 = \$3,975,905$ or a $+2.65\%$ contribution to portfolio return

- *Option approach:* $387 \times [\max(2660 - 2437.98, 0) - 48.50] \times 100 = \$6,715,224$ or a $+4.48\%$ contribution to portfolio return

The option approach was much more attractive than the futures approach in this example because the realized move in the underlying was so large. In other words, the option was underpricing subsequent volatility. However, most of the time, options tend to trade at a premium, a phenomenon known as the "volatility risk premium" (VRP). One way to measure the VRP is to compare option implied volatility to subsequent realized volatility. Historically, this spread is significant and positive, meaning implied volatility is on average a few percentage points higher than historical realized volatility and regular purchasers of index options tend to lose money. Because futures contracts are not exposed to the VRP, they will tend to be less expensive hedging instruments than put options for the same amount of linear exposure reduction. Additionally, transaction costs on futures are far lower than transaction costs on options.

The moral of the story is that when evaluating linear hedges like futures versus non-linear hedges like options (or various combinations of options), portfolio managers should:

- Evaluate apples-to-apples by comparing the net linear exposure of the option positions to the same exposure with futures.
- Use options-based methods when they have a view or preference on risk factors only accessible via options (e.g., volatility).

Bond portfolio hedging with U.S. treasury futures

In this case study, we discuss how portfolio managers may apply U.S. Treasury futures to alter the interest-rate sensitivity of a bond portfolio.

Table 2 shows the details of a simple illustrative bond portfolio worth \$133 million, yielding 4.55%, and comprised of all USD-denominated securities as of August 31, 2023. The portfolio is comprised of investment-grade securities, including U.S. Treasuries, agencies, supnationals, as well as corporate and financial sector debt instruments. While diversified bond portfolios typically contain a lot more securities than the 10 securities in this illustrative case, the hedging considerations and conclusions are not impacted by the choice of this easy-to-overview portfolio.

The portfolio's overall effective duration, labeled as option-adjusted duration in the table is 5.31 years, and the individual securities' time to maturity and durations fall in the ranges of 2.4–9.2 years and 2.2–7.4 years, respectively.



Table 2 Bond Portfolio as of August 31, 2023

ISIN Code	Security name	Issuer	Sector	Callable	Maturity	Price	Accrued interest	Face value	Market value	Yield to worst	Option-adj. duration	DV01
US91282CBH34	T 0 % 01/31/26	U.S. Treasury	Government	No	01/31/2026	90.2420	0.0326%	10,000,000	9,027,460.90	4.70%	2.34	2,113.33
US912828Z781	T 1 1 V 01/31/27	U.S. Treasury	Government	No	01/31/2027	90.7110	0.1304%	10,000,000	9,084,143.50	4.46%	3.24	2,945.99
US91282CDW82	T 1 54 01/31/29	U.S. Treasury	Government	No	01/31/2029	87.9220	0.1522%	10,000,000	8,807,417.40	4.27%	5.02	4,423.09
US912828ZQ64	T 0 A 05/15/30	U.S. Treasury	Government	No	05/15/2030	79.3120	0.1851%	20,000,000	15,899,424.40	4.20%	6.36	10,104.08
US91282CFV81	T 4 % 11/15/32	U.S. Treasury	Government	No	11/15/2032	99.9530	1.2218%	20,000,000	20,234,961.40	4.13%	7.45	15,064.93
US3130AFFX04	FHLB 3 V 11/16/28	Fed. Home Loan Bank	Agencies	No	11/16/2028	95.0970	0.9479%	10,000,000	9,604,491.70	4.31%	4.65	4,461.29
US3135G05Q27	FNMA 0 V 08/05/30	Fannie Mae	Agencies	No	08/05/2030	79.3530	0.0632%	20,000,000	15,883,238.80	4.36%	6.51	10,336.81
US4590581C89	IBRD 0 V 05/14/30	IBRD	Supranationals	No	05/14/2030	79.9480	0.2601%	20,000,000	16,041,613.80	4.36%	6.29	10,085.36
US037833BY53	AAPL 3 V 02/23/26	Apple Inc.	Industrials	Yes	02/23/2026	96.1480	0.0722%	10,000,000	9,622,022.20	4.92%	2.25	2,163.03
US172967ME81	C 3 98 03/20/30	Citigroup	Financials	Yes	03/20/2029	92.0350	1.7799%	20,000,000	18,762,988.80	5.67%	4.75	8,903.04
Total portfolio									132,967,762.90	4.55%	5.31	70,600.94

Data obtained from Bloomberg. The calculations are those of the authors



Given the securities' market values, we can also determine the portfolio's DV01, i.e., dollar sensitivity with respect to 1 basis point yield change:

$$\$132,967,763.90 \times 5.31 \times 0.0001 = \$70,600.94.$$

This means that our portfolio of \$133 million would lose about \$71,000, roughly 0.05% of the portfolio value.

Figure 1 illustrates the U.S. Treasury yield curve as of August 31, 2023. The yield curve at that point is inverted as the Federal Reserve (Fed) had hiked the Fed Fund rate multiple times to fight inflation, while the market is pricing in a change in the hawkish monetary policy toward an easing policy (i.e., lowering interest rates). Because market expectations are sensitive to inflation and job market reports, the portfolio manager is concerned about the market expecting easing to start too soon. Should these market expectations change, the yield levels would increase, and the yield curve could become less inverted.

Given these concerns, the portfolio manager decides to reduce the portfolio duration, and wants to initiate a 1 month horizon Treasury futures-based interest rate risk hedge at the end of August, by using the 2023 December Treasury futures contracts, the nearest actively traded month at that time that was practical for a one-month horizon hedge. Table 3 shows

the 2 year, 5 year, and 10 year Treasury futures contracts' key characteristics as of August 31, 2023.

It is important to note that the DV01 of one futures contract is determined by the cheapest-to-deliver (CTD) bond, and is best estimated as

$$DV01 = \text{Contract Size} \times \text{CTD Bond's Effective Duration} / \text{CTD Conversion Factor}.$$

It is interesting to note that while the duration of the 5 year contract's CTD bond is more than twice that of the 2 year contract, the DV01s of the 2 year and 5 year contracts are quite similar. The reason is that the 2 year contract's size is twice that of the 5 year contract's size.

If the portfolio manager wanted to reduce the portfolio's duration by 1 year by using 5 year Treasury futures, then the aim would be to reduce the portfolio DV01 by $1 \times \$132,967,763 \times 0.0001 = \$13,297$, and that could be achieved by selling $\$13,297 / \$43.33 = 307$ of the 5 year Treasury futures contracts.

The portfolio manager, however, decides to fully hedge all the Treasury interest-rate sensitivity of the portfolio. That is the portfolio wants to reduce its DV01

Fig. 1 U.S. Treasury Yield Curve as of August 31, 2023. Data obtained from Bloomberg. The yield curve is constructed by the authors

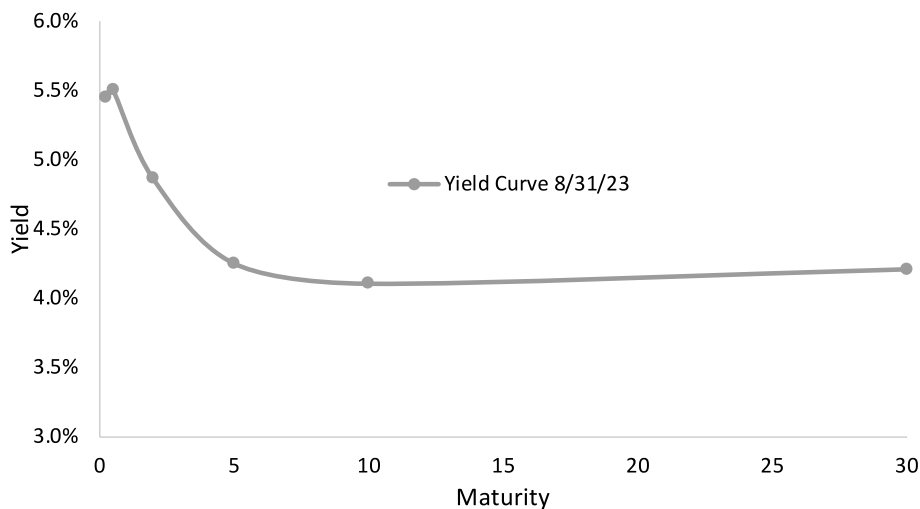


Table 3 Treasury futures characteristics as of August 31, 2023

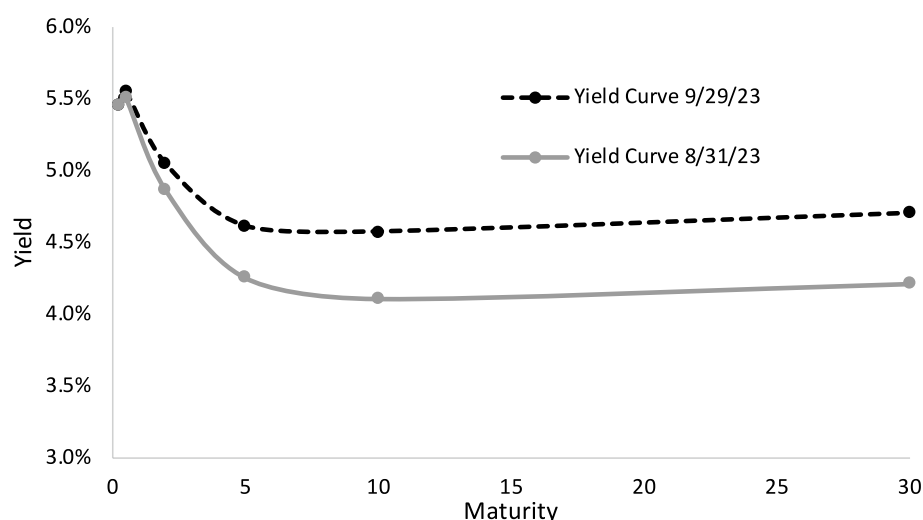
Ticker	Futures contract	Underlying	Contract size	Price	1 Contract value	Cheapest-to-deliver	CTD Conversion factor	CTD Bond OAD	DV01 of 1 contract
TUZ3	US 2YR NOTE (CBT) Dec23	US 2yr 6%	\$ 200,000	101.9023	\$ 203,805	T 3.5 9/15/25	0.9590	1.89	39.33
FVZ3	US 5YR NOTE (CBT) Dec23	US 5yr 6%	\$ 100,000	106.9219	\$ 106,922	T 4 2/29/28	0.9272	4.02	43.33
TYZ3	US 10YR NOTE (CBT) Dec23	US 10yr 6%	\$ 100,000	111.0313	\$ 111,031	T 4.125 8/31/30	0.9003	5.99	66.52

Data obtained from Bloomberg. The calculations are those of the authors

CTD = cheapest to deliver; DVO1 = dollar value of 1 basis point



Fig. 2 U.S. Treasury Yield Curve as of August 31, 2023, and September 29, 2023. Data obtained from Bloomberg. The two yield curves are constructed by the authors



of \$70,600.94 to zero. The number of contracts to sell, depending on which futures the portfolio manager chooses, would be as follows:

- 2 year contract (TUH4): $70,600.94/39.33=1795$, or
- 5 year contract (FVH4): $70,600.94/43.33=1629$, or
- 10 year contract (TYH4): $70,600.94/66.52=1061$ contracts.

Figure 2 shows how the yield curve moved over the month of September, justifying the portfolio manager's initial concerns. While the front end of the curve remained practically unchanged, the curve "bear steepened", as the 2 year, 5 year, and 10 year rates have increased by 18 bps, 36 bps, and 46 bps respectively. Figure 3 shows the daily history of the Treasury yields, futures prices, and performance of the futures contracts over the month of September.

Table 4 shows the portfolio's value and performance by the end of September 2023, without any derivative hedges. The portfolio's value declined from about \$133 million to \$130 million, as the portfolio's yield-to-worst increased by 42 basis points to 4.97%. The total monthly profit/loss (P/L) is -1.89%, or (\$2,518,736) that includes a coupon payment of \$398,000 for the Citibank bond, besides the overall market value change and coupon accruals.

Table 5 provides a comparison of how the hedges would have performed if the portfolio manager had utilized either the 2 year, 5 year, or 10 year contracts to hedge the portfolio. The column labeled "\$ P/L on Bond Portfolio and Futures" displays the sum of the P/L on the short futures contract added to the (\$2,518,736) overall negative performance of the bond portfolio. While all three futures transactions DV01 were set equal to the portfolio's DV01, the 2 year contract obviously would have been the poorest choice. This is not surprising, since the yield curve did not shift up

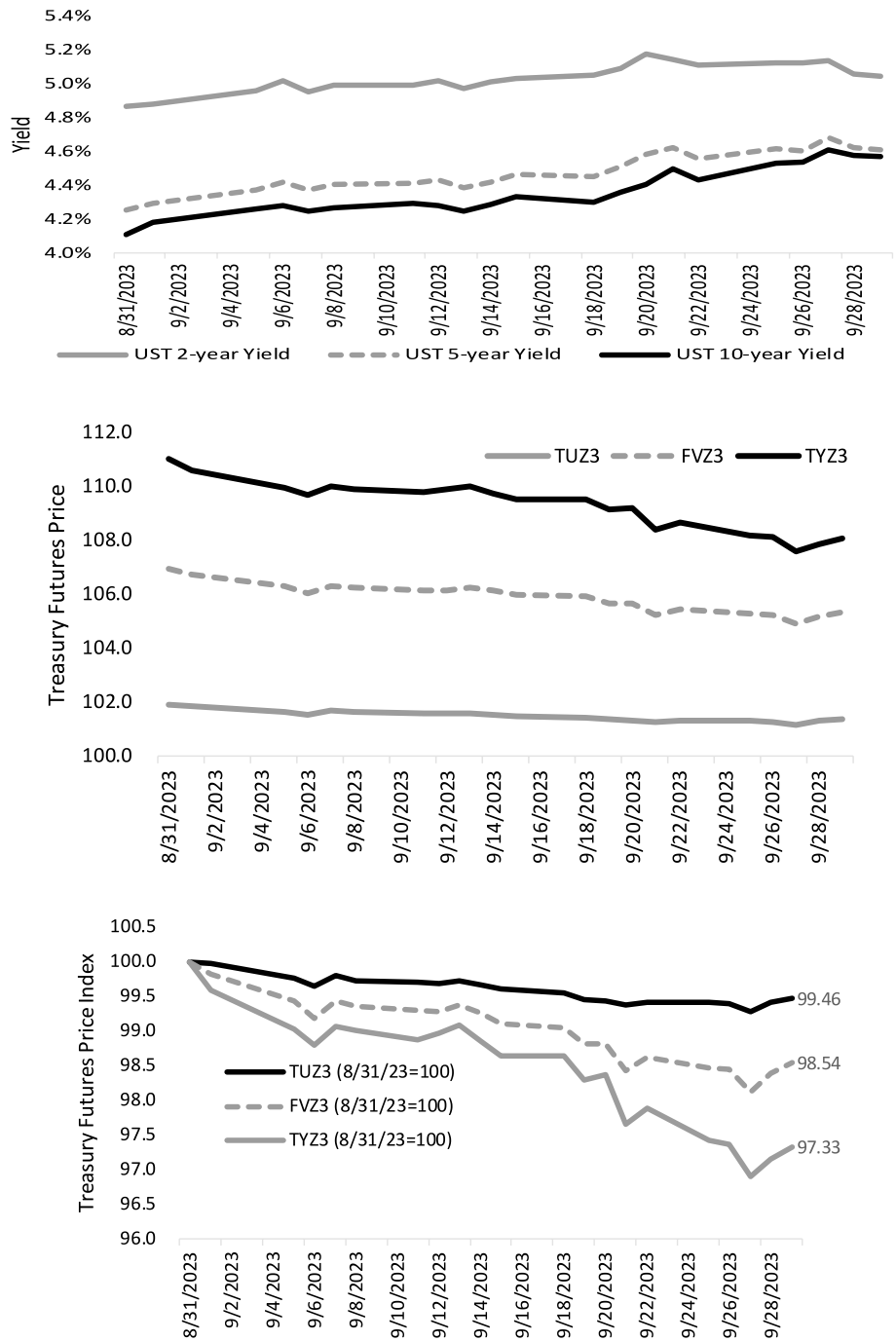
in parallel manner, but the front remained unchanged, and longer dated yields increased by more. The 2 year Treasury yield increased by 18 basis points in September, much less than the 42 basis points yield increase of the portfolio. The 5 year and 10 year Treasury rates' increase of 36 basis points and 46 basis points were closer to the portfolio's overall yield increase. In fact, if the par yield curve steepens, the forward rates underlying the Treasury futures price changes increase by even more.

Given the portfolio's initial duration of 5.31 years, it is intuitive to expect that the 2 year Treasury futures would not be the most intuitive choice; the 5 year or 10 year contracts would be more natural choices—see their CTD bonds' durations of 4.02 and 5.99 years in Table 3.

To explore this further, Table 6 displays the bonds portfolio's key rate duration profile as of August 31. Based on this information, we can see that the portfolio's overall DV01 \$70,601 is mostly concentrated around the 5 year and 10 year key rates, based on Bloomberg's Portfolio Administration tool. Instead of trading with only one of the available futures contracts, the portfolio manager could also determine a basket of 2 year, 5 year, and 10 year contracts such that they best match the portfolio's key-rate DV01 profile, as shown in Table 7. By simultaneously shorting 100, 17, and 992 contracts of the 2 year, 5 year, and 10 year Treasury futures, the portfolio's key rate DV01 profile could be closely match, resulting in an overall \$561,188, or +0.42% P/L net of hedge. While the portfolio manager could successfully eliminate the adverse impact of the yield curve change, could preserve the positive carry of the portfolio over September.



Fig. 3 U.S. Treasury Yields, Treasury Future Prices, and Futures Price Changes from August 31 to September 29, 2023. Data obtained from Bloomberg. The yield curves were constructed by the authors



Using options for tail risk hedging

Options markets allow portfolio managers to efficiently shape the probability distribution of returns. In exchange for paying a premium to the seller of an option, the buyer of an option can create a contingent payoff for specific market events of interest. In this section, the use of options to hedge tail risks in financial markets is illustrated.

By *tail risk* we generally mean financial market outcomes that are rare, but whose consequence can be large. Since these events are rare, it is usually very difficult to make a prediction of when and how large such events will occur. However, this does not change the importance of having some securities or strategies in a portfolio that will perform well in such events to provide robustness to the overall portfolio. Tail risk hedging, by definition, is a “just in case” investment strategy as compared to “just in time” investment strategies which rely on responding to an adverse event as



Table 4 Portfolio performance from August 31 to September 29, 2023

Security Name	YTW 8/31/23 (%)	YTW 9/29/23 (%)	Price of 8/31/23	Price of 9/29/23	Accrued Int. 8/31 (%)	Accrued Int. 9/29 (%)	Face value	Market value	Price return (%)	accr. int. return (%)	Total return (%)
T 0 % 01/31/26	4.70	4.97	90.2420	90.0080	0.03	0.06	10,000,000	9,007,117.90	-0.26	0.03	-0.23
T 1 J4 01/31/27	4.46	4.77	90.7110	90.0390	0.13	0.25	10,000,000	9,029,171.70	-0.74	0.12	-0.61
T 1 % 01/31/29	4.27	4.65	87.9220	86.4300	0.15	0.29	10,000,000	8,672,483.70	-1.70	0.14	v1.53
T 0 54 05/15/30	4.20	4.63	79.3120	77.3910	0.19	0.24	20,000,000	15,525,414.60	-2.42	0.05	-2.35
T 4 V 11/15/32	4.13	4.61	99.9530	96.4530	1.22	1.56	20,000,000	19,602,216.80	-3.50	0.34	-3.13
FHLLB 3 % 11/16/28	4.31	4.67	95.0970	93.5760	0.95	1.22	10,000,000	9,479,475.00	-1.60	0.27	-1.30
FNMA 0 % 08/05/30	4.36	4.81	79.3530	77.2900	0.06	0.14	20,000,000	15,485,222.20	-2.60	0.07	-2.51
IBRD 0 % 05/14/30	4.36	4.78	79.9480	78.0440	0.26	0.33	20,000,000	15,675,397.20	-2.38	0.07	-2.28
AAPL 3 % 02/23/26	4.92	5.26	96.1480	95.5330	0.07	0.34	10,000,000	9,587,605.60	0.64	0.27	-0.36
C 3.98 03/20/30	5.67	6.20	92.0350	89.8130	1.78	0.12	20,000,000	17,986,922.20	-2.41	0.33	-2.01
Total Portfolio	4.55	4.97					130,051,026.90		-2.10	0.18	-1.89

Data obtained from Bloomberg. The yield curves were constructed by the authors

it occurs. In other words, using options for tail risk hedging provides a portfolio manager with the ability to plan in advance, rather than react to the adverse event as it is happening. Options markets are perfectly suited for such risk management applications.

Adverse events can be different for different portfolios.² For any adverse event, by committing a small amount of premium to asymmetric options-based strategies helps the underlying portfolio during the period of interest and provides both protection and the ability to take advantage of opportunities via option monetization and redeployment. Such hedging, of course, is not free. For the benefit of getting the protection, the investor normally must pay something (e.g., an option premium, either on a set schedule, or by committing capital for protective strategies for a fixed horizon in advance). It is important to realize that once the risk factors of interest are identified, then options on those systematic risk factors can be utilized to reduce the systematic tail risks. Identification and quantification of risk factor exposures is thus the logical first step in designing a tail hedge. For instance, one could use options on the S&P 500 or other market indices if the primary risk factor of interest is aggregate large cap equity beta, or other indices (e.g., options on the Nasdaq 100 index) if the risk is primarily technology sector exposure. Since options are time decaying assets, the potency of the hedge must be maintained by purchasing new options as old options expire.

When an adverse market event occurs, the options may rise significantly in value; portfolio managers can choose to do nothing if the view is that the hedge is still needed, or monetize it by selling it in the market, and redeploying the proceeds into the markets or other investments, or just using the cash flows to meet other liabilities. In other words, having options-based hedges during the event in question thus provides endogenous liquidity when such liquidity is valuable for the portfolio. A combination of both systematic and discretionary monetization strategies may be used to monetize the increase in value of the options.

In this illustration, we provide a typical structure of a tail hedging program for hedging equity risk. We consider the problem of a portfolio manager who owns equities and wants to hedge out downside risk. Let's consider a portfolio manager overseeing a \$100 million investment in the S&P 500 index, via an exchange-traded fund such the SPDR S&P 500

² For instance, during the 2008-2010 financial crisis, portfolio managers who had overweight credit exposure suffered when credit spreads widened. On the other hand, when inflation suddenly increased in 2021 and 2022, portfolio managers who had been relying on bond markets to diversify their portfolios suffered from sharply rising bond yields. During the COVID-19 pandemic, the sudden decline in equity markets, especially in March 2020, created a significant adverse tail event for equity markets in general.



Table 5 Performance of individual futures trades as hedge

Contract	DV01 of futures	Traded # contract	Futures price 8/31/23	Futures price 9/29/23	P/L on 1 contract	P/L on traded futures	\$ P/L on bond portfolio and futures	% P/L on bond portfolio and futures (%)
US 2YR NOTE (CBT) Dec23	39.33	-1795	101.9023	101.3555	-1,093.75	\$ 1,963,281	\$ (555,455)	-0.42
US 5YR NOTE (CBT) Dec23	43.33	-1629	106.9219	105.3594	-1,562.50	\$ 2,545,313	\$ 26,577	0.02
US 10YR NOTE (CBT) Dec23	66.52	-1061	111.0313	108.0625	-2,968.75	\$ 3,149,844	\$ 631,108	0.47

Data obtained from Bloomberg. The calculations are those of the authors

Table 6 Bond portfolio key-rate duration profile as of August 31, 2023

Security name	Option-Adj. duration	OAD contribution	KRD 6M	KRD 2Y	KRD 5Y	KRD 10Y	KRD 20Y	KRD 30Y
T 0 % 01/31/26	2.34	0.16	-0.04	1.96	0.42	0.00	0.00	0.00
T 1 !! 01/31/27	3.24	0.22	-0.03	1.60	1.66	0.00	0.00	0.00
T 1 % 01/31/29	5.02	0.33	-0.02	-0.13	4.67	0.50	0.00	0.00
T 0 % 05/15/30	6.36	0.76	-0.03	-0.19	4.16	2.42	0.00	0.00
T 4 % 11/15/32	7.45	1.13	0.00	0.00	1.15	6.29	0.00	0.00
FHLB 3 % 11/16/28	4.65	0.34	-0.01	-0.05	4.47	0.23	0.00	0.00
FNMA 0 % 08/05/30	6.51	0.78	-0.03	-0.17	3.96	2.75	0.00	0.00
IBRD 0 % 05/14/30	6.29	0.76	-0.03	-0.17	4.12	2.37	0.00	0.00
AAPL 3 % 02/23/26	2.25	0.16	-0.01	1.89	0.37	0.00	0.00	0.00
C 3.98 03/20/30	4.75	0.67	0.00	-0.01	4.18	0.58	0.00	0.00
Total portfolio	5.31	5.31	-0.01	0.30	3.03	1.99	0.00	0.00
Key-Rate DV01	70,601		-159	3,989	40,289	26,461	0.00	0.00

Data obtained from Bloomberg. The calculations are those of the authors

ETF Trust (SPY) or the iShares Core S&P 500 ETF (IVV). Assume also that the portfolio manager (1) seeks a strategy that allows the portfolio itself (without the hedge) to absorb the first 20% of potential losses within their portfolio, (2) requires protection against any further decline if the portfolio's value drops below \$80 million within a year, and (3) desires a dependable tail hedge mechanism, one that is highly likely to activate and compensate for losses if the S&P 500 index decreases by 20% or more. This scenario assumes that the portfolio manager prefers not to sell or decrease the portfolio's market holdings as a means to mitigate risk. This stance by the portfolio manager may be due to optimism that the market will rebound, fearing that exiting now could mean missing out on future gains, and/or selling the investments could result in taxable events on unrealized

gains, presenting an additional financial burden. To implement this hedging strategy, the portfolio manager can look to buy an out of the money put option on the S&P 500 index. The portfolio manager has other choices, such as options on the SPY ETF itself, or even options on the S&P 500 index futures. The portfolio manager can also create a custom over-the-counter (OTC) option if the portfolio manager has a relationship with a prime broker or OTC derivative counterparty. Finally, the portfolio manager can create less reliable but potentially cheaper hedges using related instruments in other related markets. This cheapening of cost, however, comes with increased basis risk, so in this illustration we will not discuss such indirect hedges (Bhansali, 1).

As a first example of a reliable tail hedge with minimal basis risk, assume that the price of the S&P 500 index is



Table 7 Performance of basket of futures trades as hedge

Contract	DV01 of futures	KRD 6M	KRD 2Y	KRD 5Y	KRD 10Y	Traded # P/L on traded contract futures	\$ P/L on bond portfolio and futures	% P/L on bond portfolio and futures	
US 2YR NOTE (CBT) Dec23	39.33	-0.01	1.91	0.04	0.00	-100 \$	109,419		
US 5YR NOTE (CBT) Dec23	43.33	0.00	0.59	3.46	0.00	-17 \$	26,229		
US 10YR NOTE (CBT) Dec23	66.52	0.00	0.00	3.59	2.40	-992 \$	2,944,275		
Key-Rate DV01 of bond portfolio		-159	3,989	40,289	26,461				
Key-Rate DV01 of futures		27	-3,953	-40,252	-26,423				
Performance of futures basket						\$	3,079,924	\$ 561,187.95	0.42%

Data obtained from Bloomberg. The calculations are those of the authors

5150.82 (price as of March 8, 2024). Assume that the portfolio manager wants to hedge the downside risk with a 20% out-of-the-money European style put option with 90 days to expiration. This is a short-dated option which is usually suitable if the portfolio manager expects a sharp and steep market shock like the one that occurred during the COVID-19 crisis.

Using the Black-Scholes formula with 5150.82 as the current price, implied volatility of 26.36%, dividend yield of 1.412% for the S&P 500, interest rates of 5.31% and strike of 4120.50 (all data from Bloomberg as of March 8, 2024), the price of this put option is 9.24 S&P 500 points, which, in percentage terms is 0.17% or 17 basis points ($9.24/5151.84 = 0.17\%$). In addition, the delta of the option is -0.033 (-3.3%), the gamma is 0.5581, the vega is 1.87, and the theta is -0.27 (these numbers use the conventions that Bloomberg uses and can be used to compute the change in the value of the option for small changes in the variables that drive the price of the option). The option also has higher-order Greeks such as the rate of change of delta with respect to time (called “Charm” or delta decay) which come into play when managing the risks of options over time.

So, a portfolio manager can hedge a \$100 million portfolio for 0.17% of \$100 million (i.e., for a dollar price of \$170,000). Since this is a European option, which can only be exercised at expiration, the portfolio manager is paid one for one for any decline beyond the 20% strike level if the market falls below the 20% strike level. Note that since the delta is 3.3%, locally the exposure is as if the portfolio manager is short \$3.3 million equivalent of the stock market. But this delta changes rapidly as the market declines or volatility increases, which tends to happen together since market declines result in increases in implied volatility.

Thus, the real potency of the hedge comes from the convexity of the option. For example, if the S&P 500 drops

20%—4120.66 the value of the hedge will increase by a large multiple of its initial cost. If we assume that the volatility remains unchanged, then because of the change in the level of the S&P 500 and the gamma of the put option, the value of the put option will increase to 4.7%, which is a 21-fold increase in value.³ But the value of options is also very responsive to the level of volatility, which we assumed above to be unchanged. It is difficult to forecast what the level of volatility is going to be for all future paths, but broadly speaking volatility rises sharply when the equity markets fall.⁴ If we assume conservatively that for each 10% fall in the market results in a 10-point increase in volatility, then increasing the implied volatility by 20% results in the value of the option increasing to 8.6%, which is a 39-fold increase in its value from its purchase price. Thus, while this selloff in the market results in a loss in the underlying portfolio of 20%, the increase in the option price would cushion a good portion of the losses, thereby providing a tail-hedge.

Using a simple Black-Scholes calculator and assumptions for the change in the underlying, the portfolio manager can calculate other scenario payoffs and see if they mitigate the risks as desired or not. For illustration, if we use a 35% decline and 80% volatility level, the new option price would be 30%, which is a whopping increase of 112 times the initial value of the option. This is how options can hedge “crash” risk, and indeed were able to do so during the

³ During the COVID-19 crisis, the S&P 500 dropped from approximately 3400 to a low of 2200, an almost 35% decline from peak to trough in approximately one month from the middle of February 2020 to the middle of March 2020.

⁴ For example, during the one month from February 2020 to March 2020, implied volatility as measured by the CBOE Volatility Index (VIX) rose sharply from 20 to 80, a four-fold increase.



COVID-19 pandemic. For other events, such as the gradual but protracted decline in the market in the 2007–2008 Global Financial Crisis, options with longer maturity would be more valuable since they give longer exposure and do not decay as quickly. In practice, portfolio managers can combine options with different strike prices and maturities. For example, suppose a portfolio manager is looking for a hedge that is maintained over time and has a 1 year horizon, and resets its strike prices partially as the market changes. The portfolio manager can buy a ladder of options of different maturities (e.g., 3 month, 6 month, 9 month, and 12 month options) each with one quarter of the notional using quarterly options expiration dates and replace expiring options with new 12 month options.

An important thing to remember is that there is a price for the convexity of these options. In the world of option trading, the convexity is known as “gamma”, and price is the time decay or “theta”. In essence, if the market status quo is maintained (meaning there are no significant changes in market levels or the volatility term structure), the value of the option will decrease over time, along with its effectiveness. So, if one month has elapsed then the price of the same option will fall to close to half its value (0.09%). Part of this change in value comes from the smaller time left to expiry, and part of the change comes from the implied volatility changing. The “potency” or the delta also decays as time passes (this is the effect of the higher-order Greek “charm” mentioned above). For example, after one month, the delta falls to only -0.02 or -2% , so now the equivalent market short position is only \$2 million on this option. This is why to maintain a tail hedge a portfolio manager has to commit new capital periodically to extend the hedge. This is not dissimilar to renewal of an insurance policy where periodic premiums are needed to maintain coverage. Of course, at expiration if the market is not below the strike price, the value of the option is exactly zero, or the insurance/hedge will have expired worthless.

The difference between the implied volatility of at-the-money options and the out-of-the-money options is called the “volatility skew”. When this illustration was created, the 20% out-of-the-money put volatility was almost twice the implied volatility for at-the-money options. Thus, another alternative to hedging with puts is to use a put-spread. In a put-spread the portfolio manager buys a higher strike put option and sells a lower strike put option. For example, the portfolio manager could buy a 5% out-of-the-money put for 0.95% premium (i.e., almost \$950,000), and sell a 10% out-of-the-money put for 0.475% (i.e., \$475,000) for a difference of approximately 0.475%. Note that the delta of the 5% out-of-the-money put is -21 , and the delta of the 10% out-of-the-money put is -10 , so the total delta of the put-spread is -11 . In other words, to obtain the same delta as the original 20% out-of-the-money put the portfolio manager only has

to invest in roughly a third (to obtain the same delta as the original) notional in the put-spread, thus reducing the cost for the put-spread to 0.16% ($0.475\%/3$), which is quite close but not the same as the price of the put.⁵ However, the put-spread has a much different payoff profile than the put and can have very different sensitivities (“Greeks”). For instance, if the market falls a large amount within a short period and does not bounce back, the portfolio manager would have been better off buying a put rather than a put-spread. On the other hand, if the market falls only by a moderate amount between the upper and lower strikes of the put-spread then the portfolio manager would do better with a put-spread than with a put. Options traders run scenario shocks to quantify the difference between such structures and optimize their decisions to ensure that the desired outcome is achieved at the lowest price.

This illustration highlights several other important aspects of tail risk hedging using options. First, the selection of the instrument and sizing must match the underlying and the objectives must be specified. The objectives can be encapsulated in terms of the underlying (here the S&P 500), the “attachment point” (here the strike of 20%), the expiry (here 3 months), and the budget (here the premium spent of 0.17% per quarter). Since the prices of options vary highly with market conditions, one must solve for these three input variables simultaneously; under certain market conditions, it might not be possible to meet all the objectives. For instance, if one is budgeting only 0.50% per annum, and the desired attachment point is 10% for one year, it might be close to impossible to find a reliable hedge. In such conditions, the portfolio manager might have to compromise by either changing the expiry of the hedge, the strike of the hedges, the mix of hedges (to include indirect hedges, which introduce basis risk) or resorting to timing of the hedges. These all create the possibility of the hedge not performing as originally desired.

Another important aspect of tail hedging arises because the value of options goes up sharply when either markets fall, or volatility rises. As discussed above, the value of a hedge can go up a 100 fold if there is a very sharp fall in the market and a shock to volatility. In such events, a portfolio manager can monetize the options fully or partially and redeploy the monetization proceeds back into the markets. By doing so, the portfolio manager can generate liquidity to purchase assets when they are cheap.⁶ Consequently, tail hedging

⁵ We should emphasize that the delta of deeply out of the money options can be quite sensitive to the inputs and the model that is used, and especially for tail-hedging applications, many of the assumptions underlying the Black-Scholes model are violated, such as the assumption that the returns are normally distributed. So, care is required in the use of the models for such applications.

⁶ For instance, during the COVID-19 crisis, any monetization performed in the middle of March 2020 could be redeployed into the equity markets. As the Federal Reserve provided massive amounts of



cannot only protect but also result in systematic rebalancing with new liquidity that is very valuable to the portfolio manager. Thus, the cost of the tail-hedge must account for the opportunity it provides when such adverse events occur, and whether such opportunity can enhance long-term returns.

While options exist in many markets and there are essentially an infinite variety of combinations of instruments that a portfolio manager can use to hedge exposures, normally it makes sense to stick to liquid markets where hedges can be quickly monetized with low transactions cost. Also counterparty risk should be kept low because financial market distress is correlated with increased stress on counterparties. For this reason, listed options markets which are traded and cleared on exchanges have become popular for large institutional hedging programs. For instance, if the underlying equity index is the S&P 500, then using listed options on the S&P 500 index are appropriate to use for tail hedging. These options markets are quite popular, and options come in many expiration dates and strike prices. The quarterly expiry options are especially popular and liquid which expire on the third Friday of the expiration month. They are “European” style, so they can only be exercised on the expiration date, and trading on these options ceases on the business day before the option expiry. For these options, the multiplier is \$100, meaning that the price of the option is multiplied by \$100 to obtain the total premium per option contract. Purchasers of options with expiries less than 9 months must pay the full option premium at purchase. For each expiration date, many strike prices are listed, with strike prices spaced out every five S&P 500 points for the near months, and 25 points for far months. These options trade between 8:30 a.m. to 3:15 p.m. central time, and other “extended” and “curb” times. Finally, these options are cash-settled, which means that once the exercise settlement value (SET) is computed using the opening prices in the market for each component of the S&P 500 index, the exercise settlement amount paid to the buyer of the option is the difference between the exercise-settlement value and the exercise price of the option, multiplied by \$100. The options prices are provided in real-time by many pricing services so portfolio managers can see in real-time what the value of their hedges is at the moment and how the total portfolio is doing in aggregate.

Finally, many options markets provide investors with a lot of different types of structures that can be used to reduce the premium cost. However, given the efficiency of the options markets, this cost reduction via creative structuring is rarely free, and investors should ensure that in order to obtain cost reduction they are not creating scenarios where they might

not have a reliable hedge, or be obligated to meet capital calls or be exposed to unwanted risks. At the end of the day, the hedge itself should be designed to be cost effective, reliable, transparent, and add to the robustness of the underlying portfolio it is hedging.

Use of equity swaps

In a very general sense, a swap is an over-the-counter contract for one party to pay the economic value of owning a specified asset in exchange for the contract counterparty agreeing to pay the economic value of owning a different asset, over a specified time period. It is a seemingly simple contract that can, however, be modified extensively to include different assets, financing arrangements, settlement conditions, and time spans. Presented below is a discussion of a particular form of swap called an equity swap. The discussion includes an explanation of what they are, their applications, how are they priced and traded, and a real-world example.

How investors use equity swaps

At a glance, an equity swap is a financial derivative contract between two parties to exchange two sets of cash flows over a defined period. One cash flow is based on the performance of specific assets, like an equity index, a customized basket of equities, or even a single stock. The second cash flow is typically a fixed financing payment.

Equity swaps can be customized to suit the specific needs and investment objectives of the involved counterparties, including the choice of the equity index or specific equities, the type and tenor of the interest rate, and the period over which of the swap is in effect. Swaps are widely used by corporations, institutional investors, and hedge funds. Given such flexibility, equity swaps can be used for several purposes.

Speculation Speculators use equity swaps to bet on the future performance of a stock, or basket of stocks, without having to own the stocks. If an investor believes stock values will rise, they can enter a long swap position to receive equity performance and pay a fixed financing cost. If an investor believes stock values will fall, they can enter a short swap position to pay equity performance and receive a fixed financing rate of return.

Hedging Investors can use equity swaps to hedge against potential losses in their positions. If an investor holds a position in a particular stock and is concerned about a short-term decline in market value, they can enter a short equity swap position. The investor would be responsible for paying the equity performance. In return, they would receive the fixed financing payments. If the asset price falls, then the short

Footnote 6 (continued)

liquidity and purchased assets, the market rallied sharply and resulted in substantial gains.



swap position would receive both the financing payments and the absolute value of the stock's decline. Given that they are hedging a preexisting investment, the use of the swap would be the economic equivalent of temporarily selling out of their existing stock investment. When the term of the swap is complete, it would then be the economic equivalent of buying the stock investment back. In this example, the swap is used to temporarily sell out of the equity investment, without actually doing so.

Asset Allocation Investors can use equity swaps to adjust their portfolio's asset allocation without actually buying or selling the underlying securities. This can be particularly useful for large institutional investors looking to rebalance their portfolios efficiently or to temporarily change their exposure to certain asset classes.

Leverage Equity swaps can be used to achieve leverage in an investment portfolio. Swap investors often do not need to provide 100% of the capital for their swap investment value. They might only be asked to provide \$2.5 million for a \$10 million position, for example. This means that investors can gain a larger exposure to the equity markets than their capital investment would normally allow. This can amplify both gains and losses, making it a strategy with higher risk but potentially higher return.

Access to Restricted Markets Equity swaps can provide investors with exposure to markets or securities that are otherwise difficult to access due to regulatory restrictions, high entry costs, or other barriers. By entering into a swap with a counterparty that has access to these markets, investors can gain exposure to the returns of the desired assets without directly acquiring them.

Tax Efficiency In some jurisdictions, equity swaps can offer tax advantages. For example, using equity swaps can sometimes defer or reduce capital gains taxes compared to directly buying and selling the underlying equity. This is a more complex use of swaps that is beyond the scope of this discussion.

Income Generation Investors can use equity swaps to generate income by receiving regular interest payments. If an investor owns a basket of equities, they can enter into a short swap agreement as the interest rate owner, where the reference asset is the equity basket that they currently own. They now receive steady interest payments and avoid the volatility associated with their equity portfolio. This example has the same effect as the hedging transaction but is done with an income objective.

Operational Risk Management and Efficiency Portfolio managers can buy or sell a swap to improve operational efficiency. Equity swaps are frequently based on broad equity baskets or indices. Portfolio managers can transact in a single instrument (the swap) with a single price that is tied to the market value of a more complex and comprehensive basket of securities, rather than buying or selling and managing

potentially hundreds of individual securities. Investing in an index directly could mean significant operational responsibilities in terms of accounting systems, risk systems, ongoing corporate action monitoring, ongoing index monitoring, and ongoing general maintenance. By entering into a swap, portfolio managers can rely on the trade execution infrastructure of a large, well-resourced trading counterparty such as major money-center bank or investment bank. If properly overseen by the portfolio manager, this can both reduce transaction costs and limit the scope for a trade being mishandled in the process of execution, booking, or maintenance. Maintenance of large stock positions, particularly when shorting a large basket of stocks, can be onerous and time consuming in that they require ongoing accounting adjustments associated with such things as stock splits and equity dividend payments.

Return Enhancement One use of swaps, to control operational risk while enhancing returns, is related to securities lending. Securities lending occurs when the owner of a stock (or other securities) temporarily lends it to a borrower. Financial institutions, such as hedge funds or investment banks, will typically borrow stocks for the purpose of selling them short, covering a failed trade, or hedging a long position. In return for lending out their securities, the owner of the stock receives a securities lending fee, which can enhance their overall returns for their investment portfolio.

Securities lending, however, introduces additional risks including counterparty risk and additional operational risk to name a few. Counterparty risk is introduced due to the possibility of a borrower defaulting on their obligation to return the borrowed securities. Operational risk occurs due to potential failures in processes, systems, or controls within the securities lending program such as errors in record-keeping, mismanagement of collateral, or failures in the management of corporate actions on the lent securities.

By making use of a swap to own the stock, rather than buying it directly, one can transfer the operational risks associated with securities lending to the swap counterparty, in exchange for sharing in some of the securities lending revenues. This allows for some degree of return enhancement from securities lending while eliminating much of the operational risk.

What is a swap: a deeper dive

The structure of an equity swap typically involves two legs, an equity leg and an interest rate or financing leg. It is, however, possible but less common, that both legs involve equities. For a typical example of an equity swap, see Figure 4.

The equity leg is tied to the return of a specific equity or basket of equities. The returns include both the capital gains or losses due to price appreciation or depreciation, and dividends from the underlying equity or equity basket.



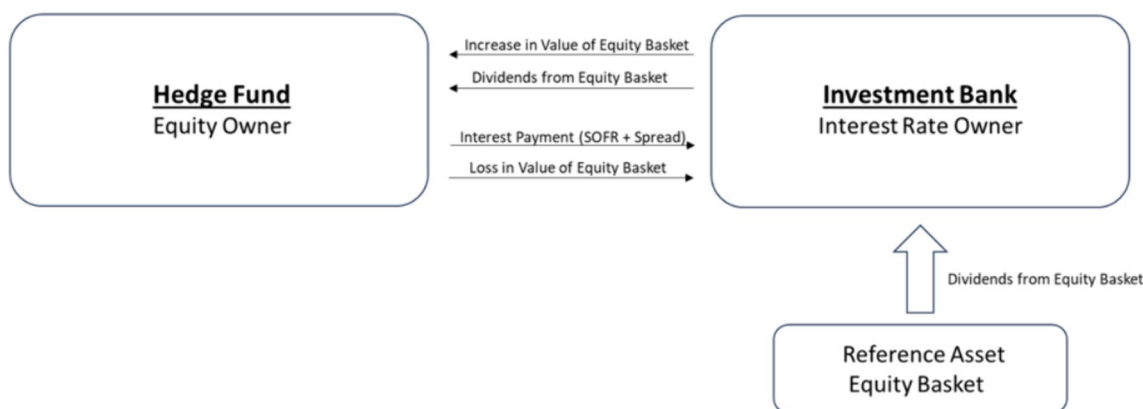


Fig. 4 Equity Swap: Hedge Fund Goes Long an Equity Basket Using a Swap

The investor in this leg of the swap benefits from the performance of the selected equities, receiving the returns as if they owned the underlying assets directly.

The interest rate or financing leg is typically linked to an interest rate that may be fixed or floating. The cash flows on this leg are determined by applying the agreed-upon interest rate to a notional principal amount, i.e., the dollar value of the selected equity or equity basket at the start of the contract. The interest rate is typically tied to a benchmark rate such as the Secured Overnight Funding Rate (SOFR) or the Federal Funds rate, but it could, in rarer cases, be tied to a longer maturity fixed income asset. The investor in this leg of the swap typically receives a cash flow based on the principal value of the equity asset and the applicable interest rate. Note a longer duration fixed-income reference asset could produce a capital loss for the owner of this leg if interest rates were to move higher. Similarly, if interest rates are negative then the owner of the interest rate leg would have a negative cash flow.

At the heart of an equity swap is the exchange of these two sets of cash flows without the need for either party to hold the underlying assets. This allows swap investors to gain exposure to, or hedge against, the performance of equity markets, manage interest rate risk, or achieve specific financial objectives without the complexities and costs associated with direct investment or additional financing arrangements.

Swaps: nomenclature and mechanics

The acronym “ISDA” stands for the International Swaps and Derivatives Association (ISDA), which is a trade organization that was founded in 1985 to represent participants in the derivatives market, including banks, investment managers, government and supranational entities, insurance companies, and corporations. The organization,

known as ISDA, is most famous for its role in creating standardized contracts for derivatives transactions, such as the ISDA Master Agreement, typically referred to as “the ISDA,” which is used globally to govern over-the-counter (OTC) derivatives transactions, such as equity swaps.

The two primary documents governing a swap transaction are the ISDA Master Agreement and the Schedule and Credit Support Annex (CSA).

The ISDA Master Agreement is a standardized document that outlines the terms and conditions between two parties engaging in an OTC derivatives swap transaction. This agreement aims to reduce legal and credit risk by providing a comprehensive legal and documentation framework. The key components and important terms of the ISDA Master Agreement include:

- *Definitions and Interpretations* This section provides precise definitions of terms used throughout the agreement, ensuring clarity and consistency in interpretation.
- *Representations and Warranties* Both parties make certain representations and warranties regarding their legal capacity, authority, and compliance with laws and regulations to enter into transactions.
- *Covenants* These are the ongoing obligations of the parties during the life of the agreement, such as the obligation to provide timely notice of certain events.
- *Events of Default and Termination Events* This crucial section lists conditions under which one party may terminate the agreement due to the other party’s failure to perform its obligations or other specified events, such as bankruptcy or failure to pay.
- *Closeout and Netting* This portion of the agreement provides mechanisms for calculating and netting off obligations in the event of a termination. This process reduces credit risk by allowing the non-defaulting party to offset positive and negative exposures to the defaulting party.



- *Transfer and Assignment* Terms under which parties may or may not assign their rights and obligations under the agreement to third parties.
- *Governing Law and Jurisdiction* Specifies the law governing the agreement and the jurisdiction for resolving disputes.
- *Taxation* Outlines the parties' responsibilities concerning the withholding and payment of taxes.
- In addition to the Master Agreement, parties typically complete a schedule that specifies additional terms, elections, and amendments to the Master Agreement to tailor it to their specific transaction that is known as the Schedule and Credit Support Annex (CSA). The CSA defines such items as eligible collateral, collateral valuation, and daily margin guidelines.

Important features of an ISDA

The ISDA Master Agreement governs the exchange of cash flows between parties, typically covering issues related to the performance of an equity investment (like a stock or a basket of stocks) versus a fixed or floating interest rate. Important considerations specific to equity swaps might include:

- *Equity Definitions* The agreement might include specific definitions related to equity swaps, such as how dividends and stock splits are treated.
- *Valuation and Payment Dates* The agreement will specify how and when the equity and interest components of the swap are valued and when payments are due.
- *Termination and Early Termination* Conditions under which the equity swap can be terminated early, and how the termination amount is calculated.

The ISDA Master Agreement and its associated documents provide a robust framework that helps manage the potentially complex risks associated with equity swaps. Now let's consider a real-world example.

Swap example

A portfolio manager (PM) wishes to capture exposure to the MSCI Daily Total Return Gross Small Cap World USD. This index is created by investment index provider MSCI. MSCI maintains numerous indices by identifying ordinary and preferred shares, share equivalents, and real estate investment trusts that are investable, accessible to global investors, and sufficiently liquid, and then creates identifiable indexes that investors can analyze, track, and invest in. Their indexes can be broadly based or categorized into geographies, sizes, sectors, industries, themes, or combinations thereof. In this example, the PM wishes to capture the total return of global small cap equities. There are about 4150 securities in the

index covering the 85th–99th percentiles of free float market capitalization in 23 developed global markets. The index is denominated in US dollars. The index is theoretical and not directly investable. An investor can attempt to capture the index performance by purchasing and managing the 4150 index constituents directly or by purchasing a mutual fund, ETF, or derivative instrument that aims to track the index.

In the example presented below, a PM enters a swap transaction with a broker dealer (BD) whereby the BD agrees to pay the performance of the index (the equity, i.e., floating leg) and the PM agrees to pay a financing cost (the interest rate, i.e., fixed leg). Simply put, the PM gets long an equity index, in this case the MSCI World Small Cap Total Return Index and does so through the use of a swap.

The swap agreement that's entered into is governed by two key documents, an ISDA and an associated CSA. The details of these contracts are negotiated prior to initiating the investment and include the specification of an equity index, a financing benchmark, a financing spread⁷, index pricing, execution fees, initial and variation margin, and the duration of the agreement.

The case presented in Table 8 is a sample real-world swap investment that was initiated on August 31, 2022, and closed on September 30, 2022. The initial (opening) terms and pricing are shown in the section titled "TRADE OPEN." The closing details of the swap investment are presented under "TRADE CLOSE." In both cases there is a trade date (when the transaction occurred), a settlement date (when all relevant transfers of assets are completed), and all transactions costs and pricing information.

In the section titled "TRADE LIFECYCLE," the details are provided concerning all of the various required cash flows related to the initiation, maintenance, and closure of the swap. Cash flows related to the maintenance of the swap will depend on the ongoing performance of the swap. In very simple terms, if the swap is profitable then the BD will send money to the investor, if it is unprofitable then the PM will send more money (post more collateral) to the BD.

Finally, toward the end of the TRADE LIFECYCLE section, the calculation of the net returns of the investment is presented.

In this example, the PM sustained a loss of approximately \$2.35 million. Let's hope this was a hedging transaction!

⁷ Typically, when an interest rate is specified, the holder of the equity leg pays that interest rate plus some additional amount known as the spread, for example SOFR plus 50 basis points.



Table 8 Sample real-world swap investment: initiated on August 31, 2022, closed on September 30, 2022

Trade open:		
Dates	Trade date (TD1)	08/31/22
	Settle date (SD1)	09/02/22
Floating leg payer	Index	MSCI Daily Total Return Gross Small Cap World USD
	Notional amount	23,607,707
	Initial price	620.994
Fixed leg payer	Index	US Federal Funds Effective Rate
	Spread to index	0.42%
	Convention	ACT/360
Other details	Opening execution fee	0.00%
	Closing execution fee	0.02%
	Initial margin amt bd	0%
	Initial margin amt pm	25%
	Transfer minimum amt	250,000
	Transfer rounding amt	10,000
Trade close:		
Dates	Trade date (TD2)	09/30/22
	Settle date (SD2)	10/04/22
	Closing price	557.572
Trade lifecycle		
Trade opened 08/31/22.		
PM wires 5,901,927 to the BD on T+1 to cover the initial margin requirements, this is 25% of starting exposure value.		
Both parties monitor the swap value on a daily basis and adjust posted collateral if needed		
If the value of swap and posted collateral drifts below the required initial margin amount by greater than 250,000, then the BD can request additional funds to “true up” the margin balances, rounded to the nearest 10,000.		
If the value of swap and posted collateral drifts above the required initial margin amount by greater than 250,000, then the PM can withdraw the accumulated gains, rounded to the nearest 10,000.		
Trade closed 09/30/22.		
Floating equity index performance leg calculation		
Notional Amount * [(Closing Price +/- Fees)/(Starting Price +/- Fees)- 1]		
23,607,707.90 * [(557.572-557.572*0.02%)/(620.994-620.994*0.00)-1]		
(2,415,289.99)		
Fixed financing leg calculation		
Notional Amount * [(Calendar-day average rate from SD1 with lookback two business days to SD2 with lookback two business days) + (Spread) / (360 days) * (number of days from SD1 to SD2)]		
23,607,707 * [(2.5175% + 0.42%) / 360 * 32]		
61,642.35		
Net transaction		
PM pays BD for 2,353,647.64 trade loss.		
BD pays back PM the initial margin amount of 5,901,927 plus/minus any amounts. Transferred during swap lifetime because the contract is closed.		

Portfolio application

This sample application makes use of an equity swap to augment an equity portfolio that replicates the S&P 500 Total Return Index, by introducing a small-cap factor tilt while respecting a specified tracking error relative to the S&P 500 Total Return Index. An investor might choose to do this if, for example, they believe that the introduction of

the so-called Fama-French risk factor “Size” will serve to improve their returns and help them systematically beat their S&P500 benchmark over time. In this example, the manager wishes to use the MSCI World Small Cap Total Return Index as a proxy for small cap stocks. As noted above however, this index includes some 4150 different stocks across 23 global markets, so the manager decides to use an equity swap to make the allocation more operationally tractable.



Table 9 Star one credit union interest rate risk profile as of December 31, 2018

Assets	Book balance	Fair value %	Est. fair value	Est. effective duration
Cash & cash equivalents	\$ 309,238,359	100	\$309,238,359	0.08
Total investments	\$ 4,094,517,870	98	\$4,012,627,513	1.88
Net loans & leases ¹	\$ 3,951,309,826	90	\$3,556,178,843	4.71
Other assets	\$ 213,169,040	99	\$211,037,350	0.50
Total assets	\$ 8,568,235,095	94	\$8,089,082,065	3.02
Liabilities				
Borrowings	\$ 684,900,000	95	\$650,655,000	2.59
Member shares (deposits) ²	\$ 6,837,609,530	91	\$6,222,224,672	3.00
Other liabilities	\$ 54,754,216	99	\$54,206,674	0.50
Total liabilities	\$ 7,577,263,746	91	\$6,927,086,346	2.94
Members' equity	\$ 990,971,349		\$ 1,161,995,718	3.49
Members' equity ratio	11.57%		14.36%	

Data obtained from S&P Capital IQ and Star One Credit Union. The calculations are those of the authors

Our portfolio manager is, however, assumed to be bound by a decision that requires that the resulting portfolio not vary too substantially from a specified strategic benchmark.

The degree of variation of the portfolio, relative to its benchmark, is assumed to be capped and quantified by its “tracking error.” The tracking error for an S&P 500 Total Return portfolio, augmented by an allocation to the MSCI World Small Cap Total Return Index, relative to its S&P 500 Total Return benchmark would be given by:

$$TE = \sqrt{\text{Var}(w_1 * SP500TR + w_2 * MSCWTR - SP500TR)}$$

where w_1 and w_2 are the respective portfolio weights, $w_1 \geq 0$ and $w_2 \geq 0$, $w_1 + w_2 = 1$, and $SP500TR$ and $MSCWTR$ are the respective daily returns of the two equity indices.

The tracking error of a portfolio relative to its benchmark is therefore the standard deviation of the differences between the daily returns of the newly created portfolio and the daily returns of the benchmark.

In this application, the portfolio manager wishes to cap the tracking error at 5%. The tracking error constraint is enforced by the inequality: $0.05 - TE \geq 0$. This ensures that the tracking error of the newly created portfolio does not exceed 5%, thereby maintaining close performance relative to the SP500TR. In the online supplement, code is provided that solves for w_1 and w_2 , that makes use of an optimizer.

The result of this optimization is a portfolio where approximately 92% of it remains allocated to the S&P500TR, while approximately 8% is allocated to a global small cap index. The resulting portfolio can now theoretically benefit from a factor tilt toward a well-documented risk factor exposure while maintaining an

acceptable degree of tracking error relative to a strategic asset allocation decision. The manager of the portfolio makes use of an equity swap to simplify a potentially operationally complex asset-allocation decision.

Consumer mortgage portfolio hedging with interest rate swaps

This case study demonstrates how the treasurer of a banking institution, specifically a credit union, may choose to hedge the fair value of the institution’s mortgage loan portfolio with interest rate swaps, and thereby mitigate interest rate risk arising from mismatched asset and liability durations for the overall balance sheet. The credit union for which this case study is written is Star One Credit Union based out of Sunnyvale, California.

Table 9 provides modeled durations for the various assets, liabilities, and equity of Star One Credit Union as of December 31, 2018.

The members’ equity line item is the value of assets less the value of liabilities (for both book and fair values. That is, Total Assets – Total Liabilities = Members’ Equity

The members’ equity ratio is members’ equity divided by total assets; that is,

Members’ Equity/Total Assets = Members’ Equity Ratio

The estimated effective duration of equity is the difference between the assumed change in assets less the assumed change in liabilities as shown below:

(Duration of Assets × Fair Value of Assets) – (Duration of Liabilities × Fair Value of Liabilities)/Members Equity = Estimated Effective Duration of Equity



Table 10 Star one credit union loan portfolio composition as of December 31, 2018

Loan Type	Book Balance	Fair Value %	Est. Fair Value	Est. Effective Duration
Unsecured Credit Card Loans & Lines of Credit	\$ 48,608,000	97%	\$ 47,149,760	0.25
Non-Federally Guaranteed Student Loans	\$ 42,982,000	97%	\$ 41,692,540	2.00
Other Unsecured Loans and Lines Of Credit	\$ 12,208,000	97%	\$ 11,841,760	1.00
New Vehicle Loans	\$ 149,669,000	97%	\$ 145,178,930	1.80
Used Vehicle Loans	\$ 129,847,000	95%	\$ 123,354,650	1.80
Other Loans and LOC Secured Non-RE	\$ 13,408,000	95%	\$ 12,737,600	2.00
Loans and LOC Secured 1st Lien 1-4 Family RE	\$ 3,235,753,000	89%	\$ 2,871,092,260	5.30
Loans & LOC Secured Junior 1-4 Family Real Estate	\$ 37,874,000	95%	\$ 35,980,300	4.00
Other Real Estate Loans and Lines of Credit	\$ 285,726,000	95%	\$ 271,439,700	3.00
Gross Loans	\$ 3,956,075,000	90.0%	\$ 3,560,467,500	4.71
Loans and LOC Secured 1st Lien 1-4 Family RE - Detail				
<i>Loans and LOC Secured 1st Lien 1-4 Family RE - Fixed Rate > 15 Years</i>			\$ 2,352,839,000	
<i>Loans and LOC Secured 1st Lien 1-4 Family RE - Fixed Rate > 15 Years % of Gross Loans</i>			59%	
<i>Loans and LOC Secured 1st Lien 1-4 Family RE - Fixed Rate > 15 Years % of Total Assets</i>			27%	

Data obtained from S&P Capital IQ and Star One Credit Union. The calculations are those of the authors

Star One's balance sheet, as shown in Table 9, demonstrates liability sensitivity as of year-end 2018. Liability sensitivity refers to the shorter modeled duration of liabilities relative to assets; hence, liabilities are primed to reprice faster than assets given any degree of interest rate movement, and ultimately, the change in fair value will be less for liabilities than it will for assets under the assumptions that led to the durations in Table 9. Alternatively, if the duration of assets were shorter than the duration of liabilities, then we would refer to the balance sheet as asset sensitive. Given Star One's interest rate risk profile shown in Table 9, a 100 basis-point increase in interest rates would result in a decrease of the fair value of equity of 3.49%.

The fair value of liabilities is often difficult to conceptualize. In an up-interest rate scenario with the objective of maximizing members' equity, one would prefer larger liability durations relative to assets, which means the fair value of liabilities would decline faster than the fair value of assets, thus increasing members' equity. The decline in fair value of liabilities suggests that the institution owes less than the implied book balance of liabilities from an economic perspective. In an alternative down rate scenario, a relatively larger overall liability duration means the fair value of liabilities (what is owed from a fair value perspective) increases faster than the fair value of assets, and therefore reduces the members' equity position.

The reason why the treasurer of a depository institution may aim to keep relatively short asset durations is the sensitivity of the balance sheet to assumptions made for the non-maturing deposit portion of liabilities (members' shares in Table 9), specifically, prepayment risk. As the regional banking turmoil of early 2023 demonstrated, non-maturing deposit liabilities may come due much earlier than expected

and therefore demonstrate much shorter liability durations than may have been modeled under various assumptions. The estimated duration for member shares is very much based on how the institution's depositors have behaved relative to prior interest rate moves; however, extreme interest rate moves, such as those observed in 2022 and 2023 provide a true test of assumed depositor behavior.

For the purpose of this case study, we may assume that Star One held no interest rate swaps as of December 31, 2018, and observe the impact of their hedge as of January 1, 2019. Table 10 shows the composition of Star One's loan portfolio as of December 31, 2018.

Adjusting the duration of consumer mortgages with interest rate swaps

Star One uses the interest rate swaps to hedge the fair value of a significant portion of their fixed residential mortgage portfolio. Under Accounting Standards Update (ASU) 2017-12 (Derivatives and Hedging), Star One may pursue the direct hedging of specified fixed rate mortgage pools with the intent to mitigate interest rate risk of long-term, fixed real estate loans. As shown in Table 10, Star One held a consumer mortgage portfolio of \$3.2 billion as of year-end 2018, and of this \$3.2 billion, approximately \$2.4 billion were fixed rate loans with maturities greater than 15 years.

The implementation of ASU 2017-12 provided significant flexibility with hedge accounting, and in Star One's case, the Credit Union may assume perfect hedge effectiveness. Under the last-of-layer method of determining the hedged portfolio, Star One can identify a portion of its fixed rate mortgage portfolio "without having to incorporate the risks arising from prepayments, defaults, and other factors affecting the



timing and amount of cash flows into the measurement of the hedged portfolio” according to prevailing financial accounting rules (FASB, 2).

Star one credit union policy targets

Credit unions engaging in derivatives transactions are expected to operate according to well documented policies and procedures commensurate with the risk profile of the activity and the institution.⁸ Star One maintains two policy targets for its derivatives positions.

Hedge Ratio: A range of 80–100% with a target of 90%.

The hedge ratio is defined as hedging instruments (defined as borrowings and derivatives with the expressed intent of hedging long-term fixed rate loans) plus equity divided by total fixed real estate loans with original terms 15 years or greater and 10 years or lower from origination date.

Average Life Ratio: A range of 70–90% with a target of 80%.

The average life ratio is defined as the hedging instrument average life including equity (which is assumed to have an average life equal to that of real estate loans) divided by total fixed real estate loans average life.

Let’s assume Star One’s interest rate risk profile takes the form of that shown Table 9. With a total asset duration of 3.02 years exceeding the total liability duration of 2.94 years, the resulting duration of equity is 3.49 years. Hence, the fair value of equity will decline by 3.49% for a 100-basis point increase in interest rates. Alternatively, a 100-basis point decrease in interest rates would result in an increase in the fair value of equity of 3.49%. The risk to equity in this case is clearly in a rates-up environment.

Treasurers and those responsible for interest rate risk in depository institutions will typically acknowledge that their job is not to guess the change in interest rates, but rather, manage the assets and liabilities of the institution in a way that mitigates undue risk to owners’ equity. For this example, let’s assume that the duration of equity of 3.49% is too high for the institution’s risk appetite and needs to be adjusted downward to reduce equity volatility. One of the options available to Star One’s treasurer is to enter into pay fixed interest rate swaps, which essentially convert fixed assets to floating rate assets, thereby shortening the overall asset duration.

Given the preferred accounting treatment discussed previously, Star One seeks to hedge 30% to 40% of its long, fixed rate mortgage portfolio—the assumption being that 30–40% of loan production in any given period will last to

maturity, and therefore, satisfy the “last of layer” accounting treatment.

Let’s assume that on January 1, 2019, Star One enters into \$955 million of pay fixed swaps with an average duration of 6.0 years for the fixed leg to match the duration of the mortgage assets being hedged. The receive floating leg resets quarterly against the Secured Overnight Financing Rate (SOFR), and the resulting duration is very short, approximately 0.25. With 40% of the long duration, fixed rate mortgages swapped to floating rate, loan portfolio and balance sheet durations take the form of those shown in Table 11.

The iteration of duration adjustments due to the added swap positions is as follows:

1. The long-dated, fixed rate mortgage portfolio duration is reduced from 6.0 to 3.67 years against a fair value balance of \$2.1 billion; this reduces the total mortgage portfolio duration from 5.3 to 3.6 years against a fair value balance of \$2.9 billion.
2. The reduction in mortgage portfolio duration reduces overall loan portfolio duration from 4.71 to 3.34 years.
3. The lower overall loan portfolio duration results in total weighted average asset duration of 2.42 years versus the pre-swapped asset duration of 3.04 years.
4. The total asset duration of 2.42 years is now less than the total liability duration of 2.94 years, and the resulting net members’ equity duration is (0.70) years. Thus, a change in interest rates will result in a materially reduced impact on the fair value of equity.

The \$955 million of pay fixed swaps placed against long duration, fixed rate mortgage assets reduce equity duration from 3.49 years to (0.70) years. The risk to equity given interest rate volatility has been significantly reduced, and the institution transitions from a liability sensitive position to an asset sensitive position.

The previous example assumed Star One entered into the \$955 million of notional swap positions as of a single point in time, but in practice, Star One enters into new pay fixed contracts quarterly depending on the amount of long duration, fixed rate mortgage production as well as the overall change in the cash flow characteristics of the mortgage portfolio.

Table 12 shows historical trends for Star One’s fixed mortgage hedging program inclusive of interest rate swaps. The hedge ratio⁹ and the average life ratio are shown in bold. Figure 5 shows how well the fair value of Star One’s interest rate swap positions move opposite of like duration U.S.

⁸ Code of Federal Regulations. (2024, February 1). 12 CFR 703.106—Operational support requirements. <https://www.ecfr.gov/current/title-12/part-703/section-703.106>.

⁹ As of this writing, Star One’s hedge ratio target range is 80% to 100%; however, this range has evolved over time and had at one time been 70% to 90%.



Table 11 Star one credit union interest rate swap adjusted balance sheet durations**Hedged Mortgage Portfolio and Resulting Est. Effective Durations - January 1, 2019**

Loan Type	Book Balance	Fair Value %	Est. Fair Value	Est. Effective Duration
Loans and LOC Secured 1st Lien 1-4 Family RE - Fixed Rate > 15 Years \$	\$ 2,352,839,000	89%	\$ 2,094,026,710	6.00
Swapped Mortgage Assets (\$ Notional)	\$ 955,000,000	89%	\$ 849,950,000	<i>Floating Leg</i> 0.25
	40.6%			
Unhedged Mortgage Assets	\$ 1,397,839,000	89%	\$ 1,244,076,710	6.00
Adjusted 1st Lien 1-4 Family RE - Fixed Rate > 15 Years Mortgage Portfolio Duration w/Swaps				3.67
Remaining Loans and LOC Secured 1st Lien 1-4 Family RE	\$ 882,914,000	89%	\$ 777,065,550	3.41
Adjusted Loans and LOC Secured 1st Lien 1-4 Family RE Duration				3.60

Impact on Total Loan Portfolio - January 1, 2019

Loan Type	Book Balance	Fair Value %	Est. Fair Value	Est. Effective Duration
Unsecured Credit Card Loans & Lines of Credit	\$ 48,608,000	97%	\$ 47,149,760	0.25
Non-Federally Guaranteed Student Loans	\$ 42,982,000	97%	\$ 41,692,540	2.00
Other Unsecured Loans and Lines Of Credit	\$ 12,208,000	97%	\$ 11,841,760	1.00
New Vehicle Loans	\$ 149,669,000	97%	\$ 145,178,930	1.80
Used Vehicle Loans	\$ 129,847,000	95%	\$ 123,354,650	1.80
Other Loans and LOC Secured Non-RE	\$ 13,408,000	95%	\$ 12,737,600	2.00
Loans and LOC Secured 1st Lien 1-4 Family RE	\$ 3,235,753,000	89%	\$ 2,871,092,260	3.60
Loans & LOC Secured Junior 1-4 Family Real Estate	\$ 37,874,000	95%	\$ 35,980,300	4.00
Other Real Estate Loans and Lines of Credit	\$ 285,726,000	95%	\$ 271,439,700	3.00
Gross Loans	\$ 3,956,075,000	90.0%	\$ 3,560,467,500	3.34

Impact on Balance Sheet - January 1, 2019

Assets	Book Balance	Fair Value %	Est. Fair Value	Est. Effective Duration
Cash & Cash Equivalents	\$ 309,238,359	100%	\$ 309,238,359	0.08
Total Investments	\$ 4,094,517,870	98%	\$ 4,012,627,513	1.88
Net Loans & Leases	\$ 3,951,309,826	90%	\$ 3,556,178,843	3.34
Other Assets	\$ 213,169,040	99%	\$ 211,037,350	0.50
Total Assets	\$ 8,568,235,095	94%	\$ 8,089,082,065	2.42
Liabilities				
Borrowings	\$ 684,900,000	95%	\$ 650,655,000	2.59
Member Shares (Deposits)	\$ 6,837,609,530	91%	\$ 6,222,224,672	3.00
Other Liabilities	\$ 54,754,216	99%	\$ 54,206,674	0.50
Total Liabilities	\$ 7,577,263,746	91%	\$ 6,927,086,346	2.94
Members' Equity	\$ 990,971,349		\$ 1,161,995,718	(0.70)
Members' Equity Ratio	11.57%		14.36%	

Data obtained from S&P Capital IQ and Star One Credit Union. The calculations are those of the authors

Treasury yields, a proxy for the offsetting fair value decline of Star One's fixed mortgage portfolio. Similarly, Figure 6 shows the fair value of Star One's interest rate swap positions relative to the value of the Bloomberg U.S. Mortgage-Backed Security (MBS) Index.

Under the accounting treatment discussed previously, there is no mark-to-market impact on Star One's income

statement since the hedge is assumed to be perfectly effective, and the net mark between the derivatives and the assets is assumed to be zero. However, the net coupon spread between the pay fixed and receive floating legs of the swaps do run through the income statement with an adjustment to loan interest income. Star One's consistent and systematic hedging of its long duration, fixed residential mortgage



Table 12 Star one credit union trended mortgage hedges, 2018–2023

Date	Total Mortgages (Hedge-eligible) (A)	Net Worth(B)	Net Mortgage Assets to be Hedged(A - B)	Borrowings Designated as a Hedge(C)	Total Interest Rate Swap Notional(D)	Total Liability & Derivative Hedges(C + D)	Hedged Loan Portfolio Weighted Average Life (years) (E)	Weighted Average Life of Interest Rate Swaps(F)	Weighted Average Life of Total Hedges((F*(C+D) + E*B)) / (B+C+D)
Jan-18	\$2669	\$985	\$1,684	\$644	\$805	\$1,449	7.52	5.19	6.13
Feb-18	\$2676	\$990	\$1,686	\$633	\$805	\$1,438	7.52	5.12	6.10
Mar-18	\$2679	\$1,000	\$1,679	\$627	\$805	\$1,432	7.56	5.03	6.07
Apr-18	\$2684	\$1,004	\$1,680	\$624	\$805	\$1,429	7.56	4.95	6.03
May-18	\$2687	\$1,009	\$1,678	\$620	\$900	\$1,520	7.56	5.06	6.06
Jun-18	\$2684	\$1,013	\$1,671	\$620	\$900	\$1,520	7.59	4.98	6.02
Jul-18	\$2676	\$1,018	\$1,658	\$598	\$928	\$1,526	7.59	4.95	6.01
Aug-18	\$2675	\$1,022	\$1,653	\$582	\$928	\$1,510	7.59	4.87	5.97
Sep-18	\$2671	\$1,027	\$1,644	\$570	\$928	\$1,498	7.59	4.79	5.92
Oct-18	\$2669	\$1,032	\$1,638	\$562	\$928	\$1,490	7.59	4.70	5.88
Nov-18	\$2660	\$1,034	\$1,626	\$540	\$943	\$1,483	7.59	4.66	5.86
Dec-18	\$2653	\$1,037	\$1,616	\$535	\$943	\$1,478	7.58	4.57	5.81
Jan-19	\$2647	\$1,039	\$1,609	\$527	\$955	\$1,482	7.58	4.53	5.79
Feb-19	\$2643	\$1,040	\$1,603	\$520	\$955	\$1,475	7.58	4.45	5.75
Mar-19	\$2646	\$1,042	\$1,603	\$499	\$955	\$1,454	7.50	4.37	5.68
Apr-19	\$2650	\$1,047	\$1,603	\$492	\$955	\$1,447	7.50	4.29	5.64
May-19	\$2667	\$1,052	\$1,615	\$480	\$967	\$1,447	7.50	4.26	5.62
Jun-19	\$2690	\$1,057	\$1,633	\$480	\$967	\$1,447	7.42	4.18	5.54
Jul-19	\$2720	\$1,061	\$1,659	\$470	\$997	\$1,467	7.42	4.24	5.57
Aug-19	\$2756	\$1,065	\$1,691	\$470	\$997	\$1,467	7.42	4.16	5.53
Sep-19	\$2786	\$1,069	\$1,716	\$470	\$997	\$1,467	7.39	4.07	5.47
Oct-19	\$2832	\$1,073	\$1,759	\$450	\$1,037	\$1,487	7.39	4.22	5.55
Nov-19	\$2864	\$1,077	\$1,787	\$430	\$1,037	\$1,467	7.39	4.14	5.51
Dec-19	\$2913	\$1,083	\$1,830	\$419	\$1,037	\$1,456	7.26	4.08	5.44
Jan-20	\$2929	\$1,088	\$1,841	\$419	\$1,112	\$1,531	7.26	4.32	5.54
Feb-20	\$2947	\$1,094	\$1,853	\$415	\$1,122	\$1,537	7.26	4.30	5.53
Mar-20	\$2965	\$1,098	\$1,868	\$415	\$1,127	\$1,542	7.23	4.29	5.51
Apr-20	\$3007	\$1,097	\$1,910	\$415	\$1,147	\$1,562	7.23	4.29	5.50
May-20	\$3049	\$1,099	\$1,951	\$425	\$1,159	\$1,584	7.23	4.27	5.48
Jun-20	\$3094	\$1,100	\$1,994	\$413	\$1,171	\$1,584	7.10	4.25	5.42
Jul-20	\$3101	\$1,108	\$1,993	\$401	\$1,199	\$1,600	7.10	4.28	5.44
Aug-20	\$3090	\$1,117	\$1,973	\$394	\$1,210	\$1,604	7.10	4.25	5.42
Sep-20	\$3069	\$1,125	\$1,944	\$245	\$1,220	\$1,465	6.90	4.22	5.38
Oct-20	\$3063	\$1,134	\$1,929	\$245	\$1,237	\$1,482	6.90	4.25	5.40
Nov-20	\$3055	\$1,143	\$1,911	\$245	\$1,247	\$1,492	6.90	4.21	5.38
Dec-20	\$3056	\$1,152	\$1,904	\$245	\$1,237	\$1,482	6.75	4.17	5.30
Jan-21	\$3054	\$1,163	\$1,892	\$245	\$1,267	\$1,512	6.75	4.20	5.31
Feb-21	\$3059	\$1,172	\$1,887	\$245	\$1,255	\$1,500	6.75	4.18	5.31
Mar-21	\$3118	\$1,182	\$1,936	\$245	\$1,245	\$1,490	6.60	4.13	5.22
Apr-21	\$3165	\$1,188	\$1,977	\$245	\$1,305	\$1,550	6.60	4.30	5.30
May-21	\$3202	\$1,195	\$2,007	\$245	\$1,280	\$1,525	6.60	4.34	5.33
Jun-21	\$3227	\$1,202	\$2,025	\$245	\$1,280	\$1,525	6.56	4.26	5.27
Jul-21	\$3234	\$1,210	\$2,024	\$245	\$1,343	\$1,588	6.56	4.38	5.32
Aug-21	\$3253	\$1,217	\$2,036	\$245	\$1,343	\$1,588	6.56	4.30	5.28
Sep-21	\$3278	\$1,223	\$2,054	\$245	\$1,323	\$1,568	6.51	4.30	5.27



Table 12 (continued)

Date	Total Mortgages (Hedge-eligible) (A)	Net Worth(B)	Net Mortgage Assets to be Hedged(A - B)	Borrowings Designated as a Hedge(C)	Total Interest Rate Swap Notional(D)	Total Liability & Derivative Hedges(C + D)	Hedged Loan Portfolio Weighted Average Life (years) (E)	Weighted Average Life of Interest Rate Swaps(F)	Weighted Average Life of Total Hedges((F*(C+D) + E*B)) / (B+C+D)
Oct-21	\$3300	\$1,227	\$2,073	\$229	\$1,366	\$1,595	6.51	4.41	5.32
Nov-21	\$3330	\$1,230	\$2,099	\$217	\$1,366	\$1,583	6.51	4.32	5.28
Dec-21	\$3344	\$1,234	\$2,110	\$207	\$1,349	\$1,556	6.49	4.30	5.27
Jan-22	\$3368	\$1,242	\$2,125	\$199	\$1,395	\$1,594	6.49	4.36	5.30
Feb-22	\$3388	\$1,250	\$2,138	\$184	\$1,420	\$1,604	6.49	4.24	5.22
Mar-22	\$2956	\$1,260	\$1,696	\$184	\$1,420	\$1,604	6.41	4.15	5.14
Apr-22	\$2970	\$1,261	\$1,709	\$174	\$1,435	\$1,609	6.41	4.28	5.22
May-22	\$2972	\$1,263	\$1,709	\$164	\$1,435	\$1,599	6.41	4.20	5.17
Jun-22	\$2973	\$1,265	\$1,708	\$164	\$1,435	\$1,599	6.41	4.11	5.13
Jul-22	\$2975	\$1,263	\$1,712	\$164	\$1,500	\$1,664	6.41	4.06	5.07
Aug-22	\$2964	\$1,262	\$1,703	\$164	\$1,455	\$1,619	6.41	4.10	5.11
Sep-22	\$2959	\$1,261	\$1,698	\$160	\$1,435	\$1,595	6.70	4.07	5.23
Oct-22	\$2950	\$1,271	\$1,679	\$160	\$1,410	\$1,570	6.70	4.06	5.24
Nov-22	\$2938	\$1,275	\$1,663	\$148	\$1,385	\$1,533	6.70	4.05	5.25
Dec-22	\$2932	\$1,276	\$1,657	\$148	\$1,370	\$1,518	7.03	4.01	5.39
Jan-23	\$2923	\$1,282	\$1,641	\$141	\$1,415	\$1,556	7.03	3.92	5.33
Feb-23	\$2915	\$1,288	\$1,626	\$134	\$1,397	\$1,531	7.03	3.90	5.33
Mar-23	\$2909	\$1,292	\$1,617	\$134	\$1,377	\$1,511	7.38	3.87	5.49
Apr-23	\$2901	\$1,296	\$1,605	\$134	\$1,322	\$1,456	7.38	3.95	5.56
May-23	\$2892	\$1,298	\$1,595	\$131	\$1,257	\$1,388	7.38	4.06	5.66
Jun-23	\$2882	\$1,300	\$1,582	\$128	\$1,302	\$1,430	7.69	3.93	5.72
Jul-23	\$2870	\$1,301	\$1,569	\$128	\$1,294	\$1,422	7.69	3.98	5.75
Aug-23	\$2863	\$1,300	\$1,563	\$128	\$1,294	\$1,422	7.69	3.90	5.71
Sep-23	\$2854	\$1,300	\$1,554	\$128	\$1,279	\$1,407	7.95	3.86	5.82
Oct-23	\$2841	\$1,294	\$1,547	\$120	\$1,289	\$1,409	7.95	3.86	5.82
Nov-23	\$2829	\$1,289	\$1,540	\$120	\$1,274	\$1,394	7.95	3.82	5.80
Dec-23	\$2825	\$1,285	\$1,540	\$120	\$1,236	\$1,356	8.20	3.85	5.97

Date	Internal Derivative Policy Targets		Hedged Loan Portfolio Weighted Average Coupon (%)	Pay Fixed Interest Rate (%)	Receive Floating Interest Rate (%)	Fair Value of Interest Rate Swaps \$(G)	Fair Value of Interest Rate Swaps % (G/D) (%)	Monthly Average 7yr Constant Maturity Treasury (%)	Bloomberg U.S. MBS Index
	Hedge Ratio(C + D)/ (A - B) Target Range: 80-100%	Average Life Ratio Target Range: 70-90%							
Jan-18	86	82	3.47	1.72	1.61	\$12	1.49	2.51	2058
Feb-18	85	81	3.47	1.72	1.74	\$14	1.79	2.78	2045
Mar-18	85	80	3.48	1.72	1.87	\$13	1.65	2.77	2058
Apr-18	85	80	3.49	1.72	2.16	\$16	2.02	2.82	2047
May-18	91	80	3.50	1.84	2.31	\$15	1.62	2.93	2062
Jun-18	91	79	3.51	1.84	2.34	\$16	1.73	2.87	2063
Jul-18	92	79	3.51	1.87	2.34	\$17	1.82	2.85	2061
Aug-18	91	79	3.52	1.87	2.33	\$15	1.61	2.84	2073
Sep-18	91	78	3.52	1.87	2.33	\$18	1.90	2.96	2060
Oct-18	91	78	3.53	1.87	2.38	\$19	2.00	3.09	2047
Nov-18	91	77	3.54	1.89	2.50	\$38	4.01	3.04	2066
Dec-18	91	77	3.55	1.89	2.59	\$23	2.39	2.75	2103
Jan-19	92	76	3.55	1.90	2.74	\$20	2.12	2.61	2120
Feb-19	92	76	3.55	1.90	2.74	\$21	2.21	2.57	2118



Applications of derivatives for portfolio risk management

Table 12 (continued)

Date	Internal Derivative Policy Targets		Hedged Loan Portfolio Weighted Average Coupon (%)	Pay Fixed Interest Rate (%)	Receive Floating Interest Rate (%)	Fair Value of Interest Rate Swaps \$(G)	Fair Value of Interest Rate Swaps % (G/D) (%)	Monthly Average 7yr Constant Maturity Treasury (%)	Bloomberg U.S. MBS Index
	Hedge Ratio(C + D)/(A - B) Target Range: 80-100%	Average Life Ratio Target Range: 70-90%							
Mar-19	91	76	3.56	1.90	2.71	\$11	1.11	2.47	2149
Apr-19	90	75	3.56	1.90	2.62	\$11	1.15	2.43	2148
May-19	90	75	3.56	1.91	2.57	(\$4)	-0.41	2.29	2175
Jun-19	89	75	3.56	1.91	2.53	(\$10)	-1.08	1.95	2191
Jul-19	88	75	3.55	1.91	2.40	(\$8)	-0.80	1.93	2200
Aug-19	87	75	3.55	1.91	2.26	(\$27)	-2.72	1.55	2219
Sep-19	85	74	3.54	1.91	2.21	(\$20)	-2.02	1.64	2221
Oct-19	85	75	3.53	1.90	2.06	(\$22)	-2.08	1.62	2229
Nov-19	82	75	3.52	1.90	1.99	(\$18)	-1.69	1.74	2231
Dec-19	80	75	3.52	1.90	1.95	(\$12)	-1.18	1.79	2237
Jan-20	83	76	3.52	1.88	1.86	(\$28)	-2.53	1.67	2252
Feb-20	83	76	3.51	1.87	1.79	(\$46)	-4.06	1.42	2276
Mar-20	83	76	3.49	1.86	1.61	(\$66)	-5.85	0.78	2300
Apr-20	82	76	3.46	1.84	1.28	(\$70)	-6.10	0.55	2314
May-20	81	76	3.45	1.83	0.89	(\$71)	-6.11	0.53	2317
Jun-20	79	76	3.43	1.82	0.75	(\$72)	-6.12	0.55	2315
Jul-20	80	77	3.41	1.79	0.31	(\$75)	-6.26	0.46	2319
Aug-20	81	76	3.38	1.78	0.27	(\$68)	-5.64	0.46	2320
Sep-20	75	78	3.34	1.77	0.26	(\$67)	-5.52	0.46	2318
Oct-20	77	78	3.27	1.75	0.24	(\$60)	-4.82	0.55	2317
Nov-20	78	78	3.20	1.74	0.23	(\$60)	-4.78	0.63	2318
Dec-20	78	79	3.12	1.73	0.22	(\$58)	-4.68	0.66	2323
Jan-21	80	79	3.01	1.72	0.23	(\$50)	-3.94	0.77	2325
Feb-21	79	79	2.94	1.72	0.22	(\$33)	-2.65	0.91	2310
Mar-21	77	79	2.90	1.72	0.22	(\$24)	-1.96	1.27	2298
Apr-21	78	80	2.88	1.69	0.19	(\$28)	-2.17	1.31	2311
May-21	76	81	2.87	1.68	0.18	(\$32)	-2.49	1.28	2307
Jun-21	75	80	2.85	1.68	0.17	(\$33)	-2.54	1.23	2306
Jul-21	78	81	2.83	1.64	0.13	(\$38)	-2.83	1.07	2320
Aug-21	78	81	2.81	1.64	0.13	(\$34)	-2.54	1.06	2316
Sep-21	76	81	2.80	1.64	0.13	(\$24)	-1.79	1.16	2308
Oct-21	77	82	2.79	1.63	0.13	(\$16)	-1.18	1.40	2303
Nov-21	75	81	2.78	1.63	0.13	(\$31)	-2.28	1.45	2301
Dec-21	74	81	2.78	1.62	0.15	(\$12)	-0.89	1.40	2299
Jan-22	75	82	2.77	1.61	0.21	\$7	0.49	1.70	2265
Feb-22	75	80	2.78	1.59	0.28	\$14	0.98	1.91	2243
Mar-22	95	80	2.78	1.59	0.39	\$45	3.20	2.15	2185
Apr-22	94	81	2.78	1.63	0.83	\$75	5.22	2.80	2108
May-22	94	81	2.79	1.63	1.14	\$68	4.71	2.92	2131
Jun-22	94	80	2.80	1.63	1.34	\$76	5.33	3.21	2097
Jul-22	97	79	2.81	1.67	2.24	\$61	4.08	2.97	2165
Aug-22	95	80	2.82	1.69	2.59	\$92	6.33	2.98	2091
Sep-22	94	78	2.83	1.69	2.87	\$125	8.71	3.64	1985
Oct-22	94	78	2.83	1.69	3.64	\$135	9.55	4.09	1957
Nov-22	92	78	2.84	1.68	4.14	\$114	8.26	3.99	2037
Dec-22	92	77	2.85	1.68	4.37	\$122	8.92	3.72	2028
Jan-23	95	76	2.86	1.74	4.68	\$104	7.34	3.59	2094
Feb-23	94	76	2.87	1.75	4.77	\$127	9.07	3.86	2039
Mar-23	93	74	2.88	1.74	4.85	\$102	7.43	3.77	2079
Apr-23	91	75	2.89	1.75	5.08	\$96	7.26	3.50	2090



Table 12 (continued)

Date	Internal Derivative Policy Targets		Hedged Loan Portfolio Weighted Average Coupon (%)	Pay Fixed Interest Rate (%)	Receive Floating Interest Rate (%)	Fair Value of Interest Rate Swaps \$(G)	Fair Value of Interest Rate Swaps % (G/D) (%)	Monthly Average 7yr Constant Maturity Treasury (%)	Bloomberg U.S. MBS Index
	Hedge Ratio(C+D)/(A-B) Target Range: 80-100%	Average Life Ratio Target Range:70-90%							
May-23	87	77	2.90	1.74	5.23	\$104	8.27	3.58	2074
Jun-23	90	74	2.91	1.83	5.28	\$120	9.18	3.85	2065
Jul-23	91	75	2.92	1.87	5.47	\$117	9.01	4.03	2064
Aug-23	91	74	2.93	1.87	5.51	\$119	9.18	4.26	2047
Sep-23	91	73	2.95	1.88	5.51	\$133	10.40	4.46	1982
Oct-23	91	73	2.95	1.94	5.55	\$133	10.29	4.82	1941
Nov-23	91	73	2.96	1.94	5.53	\$112	8.77	4.53	2042
Dec-23	88	73	2.98	1.96	5.57	\$86	6.95	4.04	2130

Data obtained from S&P Capital IQ, Star One Credit Union, and Bloomberg. The calculations are those of the authors.

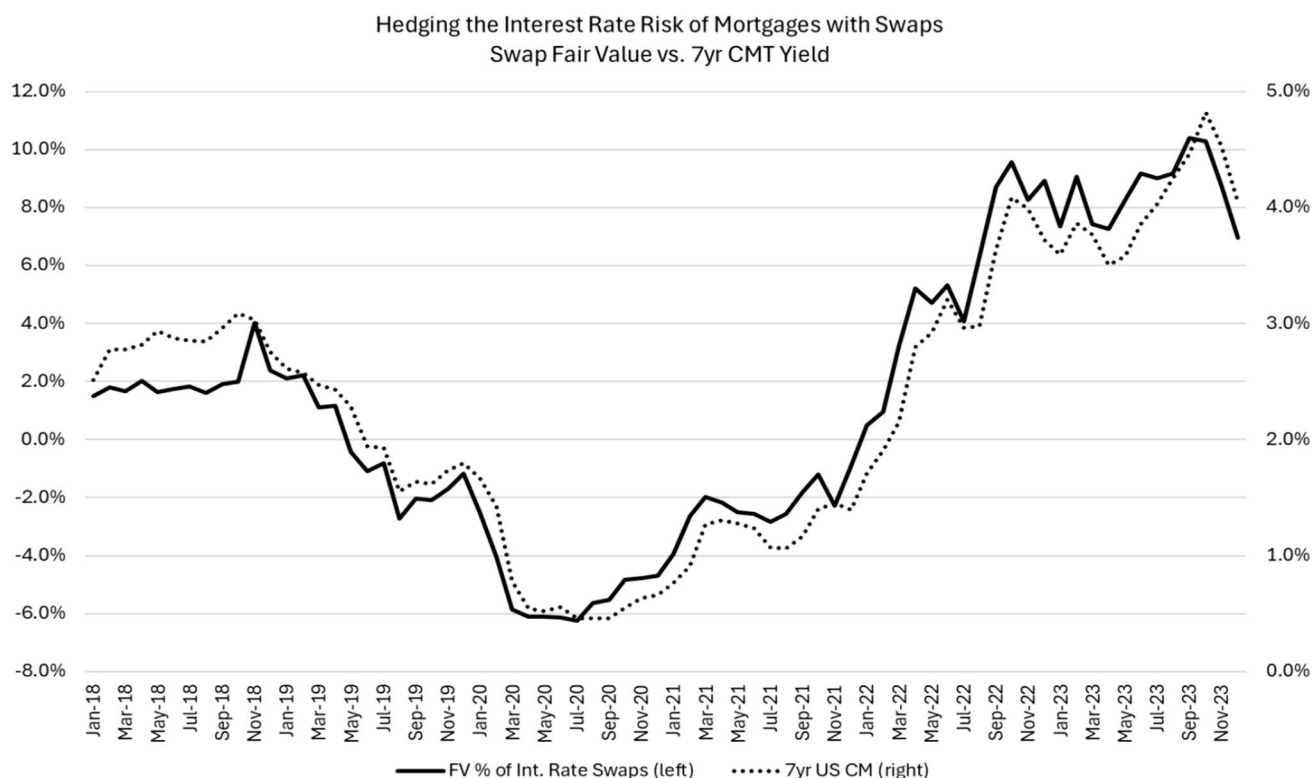


Fig. 5 Fair Value of Interest Rate Swaps vs. 7 Year CMT Yield. Data obtained from S&P Capital IQ, Star One Credit Union, and Bloomberg. The calculations are those of the authors

portfolio helped to protect a large portion of its net interest income when interest rates rapidly increased in 2022 and 2023.

Figure 7 shows the high-level income statement impact of the net swap coupon spread relative to total net interest income. As funding costs rose significantly in 2022 and 2023, Star One benefited from the floating leg of the swaps since the coupon rose right along with short-term interest

rates (see the Receive Floating Interest Rate Column in Table 12 for 2022 and 2023). As of Q4 2023, the net coupon spread income from Star One's interest rate swaps provided approximately 66.7% of Star One's net interest income. Without the swap positions, Star One's net interest income would have struggled to remain positive in the latter half of 2023. This income benefit is a direct realization of the adjusted balance sheet durations because of the



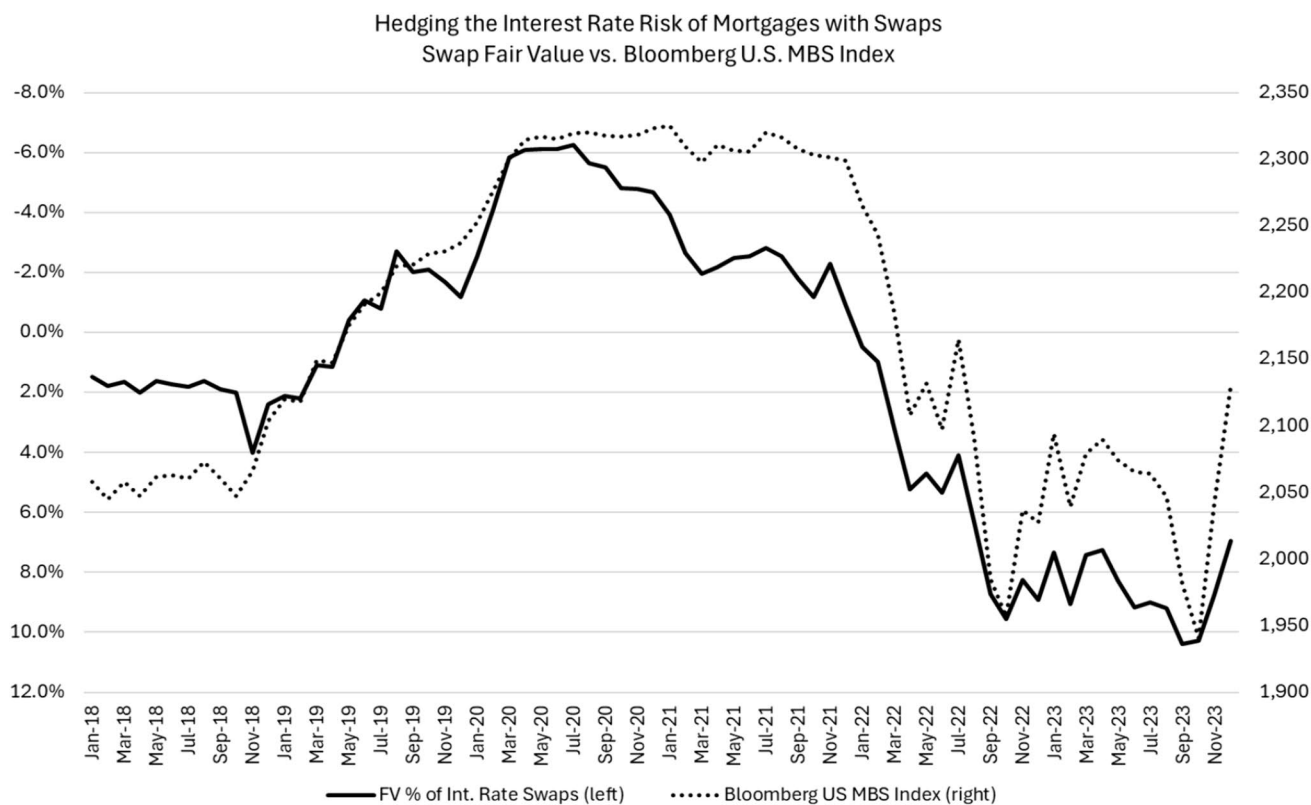


Fig. 6 Fair Value of Interest Rate Swaps vs. Bloomberg U.S. MBS Index. Data obtained from S&P Capital IQ, Star One Credit Union, and Bloomberg. The calculations are those of the authors

interest rate swaps. The ability to reprice assets faster in the rising rate environment helped to offset higher funding costs on the liability side of the balance sheet.

Most financial institutions continue to grapple with much higher funding costs while unable to reprice long-duration assets originated during the historically low interest rate environment. Institutions such as Star One have been able to navigate the uncertainty with much more flexibility due to their consistent and prudent risk management of interest rate risk. Although hedging reduces upside opportunity while also reducing downside risk, Star One's hedge program provides an excellent example of how prudent risk management over the long run helps to ensure an institution remains a going concern through volatile economic environments.

Summary

In this article, we provide strategic uses of derivatives to control and mitigate portfolio risks. The first shows the application of stock index futures and put options for hedging equity. This includes a detailed example where an equity portfolio manager employs futures and options to

balance portfolio beta relative to a benchmark index, illustrating how derivatives can be tailored to specific portfolio needs while reducing market exposure.

The second illustration involves U.S. Treasury futures to adjust the interest-rate risk of bond portfolios. The methodologies for employing Treasury futures to manage duration and interest-rate sensitivity provides a practical guide for portfolio managers to align their portfolios with interest-rate expectations.

The application of options for tail risk hedging is then demonstrated. How options can protect against rare but severe market movements, thus adding a layer of security to investment strategies is explained. This application highlights the flexibility of options in portfolio management, allowing for customized risk management approaches based on specific portfolio characteristics and risk tolerance.

The use of equity swaps in active equity portfolio management is then covered. The mechanics of equity swaps and their use in gaining exposure to market indices or specific sectors without direct investment, thus enhancing portfolio diversification and managing specific equity risks effectively is demonstrated.



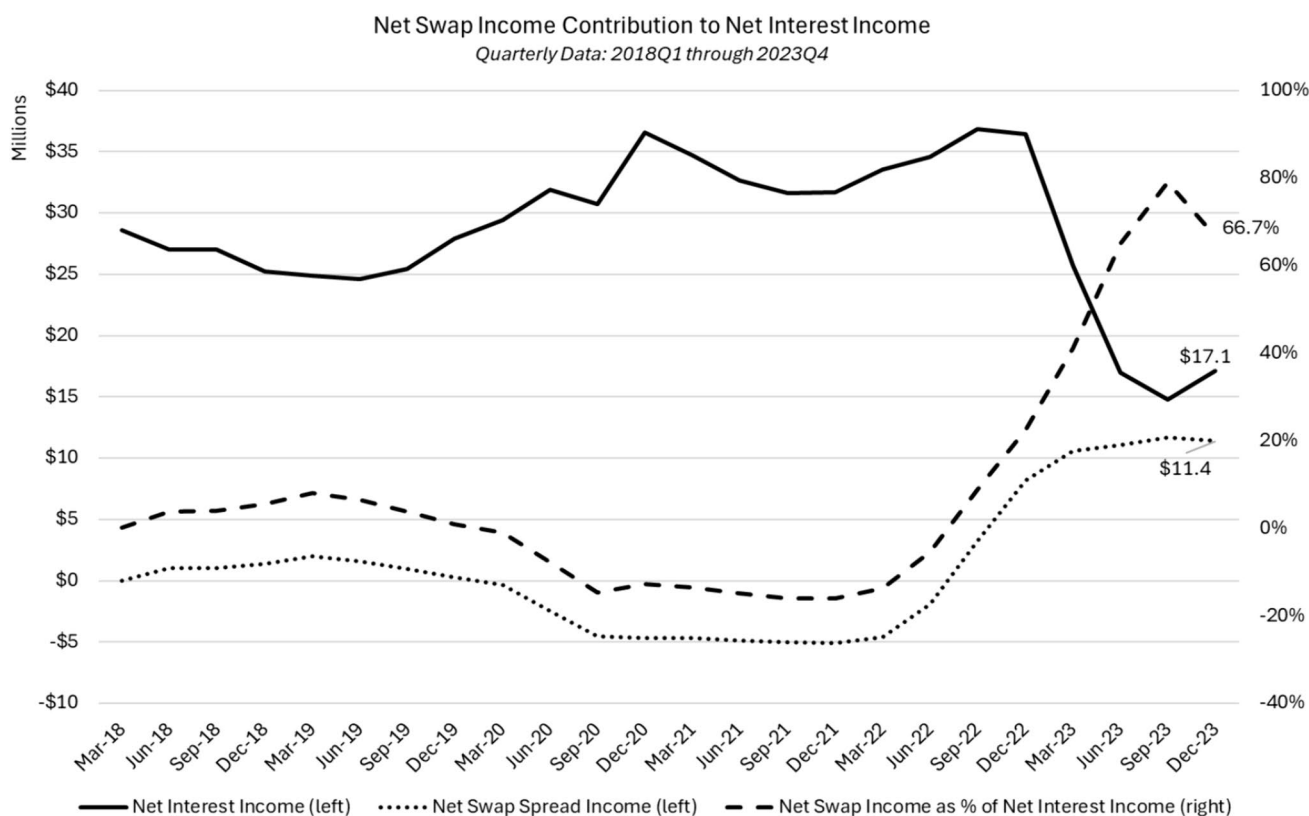


Fig. 7 Net Interest Rate Swap Contribution to Net Interest Income. Data obtained from S&P Capital IQ, Star One Credit Union, and Bloomberg. The calculations are those of the authors

The final illustration focuses on how treasurers of credit unions can employ interest-rate swaps to hedge against the interest-rate risk of consumer mortgage portfolios. This case is particularly insightful as it lays out a scenario where a credit union might use swaps to stabilize income from interest payments by exchanging payments on a variable-rate basis for payments on a fixed-rate payment basis. This strategy is crucial for managing the financial stability of institutions that have significant exposures to loans with fluctuating interest rates, ensuring consistent income regardless of market volatility.

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Vineer Bhansali is Founder and Chief Investment Officer of LongTail Alpha, LLC, an investment management firm based in Newport Beach, CA which is focused exclusively on risk-mitigation strategies. Over his 30 plus-year investment career, he worked at Citibank (Hybrid Options Trading Desk), Salomon Brothers (Fixed Income Arbitrage Group), CSFB (Proprietary Trading Group), and PIMCO (Managing Director and Head of the Quantitative Portfolios Team). He has authored six books on finance and more than 40 articles covering option pricing, fixed income, tail hedging, and asset allocation in noted journals. He has received the Graham and Dodd Scroll Award from the *Financial Analysts Journal*. Vineer received his Ph.D. in Theoretical Physics from Harvard University in 1992 and M.S. and B.S. degrees in Physics from Caltech in 1987. He currently serves on the Investment Committee of the Margaret A Cargill Philanthropies, is a Member of The Board of Directors of The Q Group and is a Trustee of the Simons-Laufer



Mathematical Sciences Research Institute and a Trustee Board Member of AIF.

Frank J. Fabozzi is a Professor of Practice at John Hopkins' Carey Business School. Frank is the editor of *The Journal of Portfolio Management*, co-editor of *The Journal of Financial Data Science*, and an editor of *Annals of Operations Research*. From 1988–2023, he served on the board of directors of BlackRock fixed income complex. He is the CFA Institute's 2007 recipient of the C. Stewart Sheppard Award and 2015 recipient of the James R. Vertin Award. He was inducted into the Fixed Income Analysts Society Hall of Fame in November 2002. Frank earned a BA (magna cum laude) and MA in economics in 1970 from The City College of New York where he was elected to Phi Beta Kappa and a PhD in economics in 1972 from the City University of New York. He has earned the designations of CFA and CPA.

Robert Harlow is the Associate Head of Global Multi-Asset Research at T. Rowe Price and a member of both the Investments Derivatives Committee and Investment Advisory Committee of the Global Allocation Fund. He is a vice president of T. Rowe Price Group, Inc., and T. Rowe Price Associates, Inc. He also manages several equity derivative mandates on behalf of broader multi-asset portfolios. Robert earned a B.S. in physics and an M.S.E. in applied mathematics and statistics from Johns Hopkins University. He earned the Chartered Financial Analyst (CFA) and Chartered Alternative Investment Analyst (CAIA) designations.

Adam Kobor is the Managing Director of Investments at New York University. He is a senior member of the investment team, primarily responsible for strategic asset allocation, private credit, and fixed income investments. Prior to joining NYU, Adam was a Director at the Rock Creek Group, focusing on asset allocation and emerging markets equity investments. Earlier in his career, he was a Senior Manager at Apple Inc., mainly responsible for risk and analytics of Apple's fixed income investment portfolio. Prior to joining Apple, Mr. Kobor worked for the World Bank, where he managed mortgage-backed securities portfolios, prepared asset allocation recommendations for various portfolios managed by the World Bank Treasury, and advised central bank clients. Adam earned a PhD from the Corvinus University, Budapest and is a CFA charterholder.

Joseph Niehaus is a Senior Vice President with the CUFS Group at Jefferies, where he leverages the Jefferies investment banking platform for the evolving financial needs of credit unions. Prior to his time at

Jefferies, Joseph held key treasury and finance roles for Sacramento, CA based community financial institutions including Golden 1 Credit Union, SAFE Credit Union, and Rabobank, NA. He began his career in banking as a Financial Institution Specialist with the FDIC. Joseph is currently a doctoral candidate with the Grenoble Ecole de Management, Grenoble, France, with a research focus on financial cooperative economics and the relationship between social factors and the value of credit union membership. He is a CFA Charterholder and a past President of the CFA Society Sacramento. He holds an MBA from the University of Nebraska, Lincoln, and a BS from Sacramento State University. Joseph also served five years in the U.S. Navy as an airborne electronic intelligence analyst.

Christopher Small is the Director of Trading at Windham Capital Management, LLC. He has worked at Windham since 2015 and in the investment management industry since 2004. Chris manages the implementation of Windham's investment solutions across domestic and foreign equities, fixed income, commodities, and currencies, and has experience in a wide variety of investment vehicles including ETF's, futures, forwards, and swaps. Prior to Windham, Chris was a senior trader and manager at Windhaven Investment Management. Chris holds a Bachelor of Arts from Middlebury College where he focused on Economics and Premedical Studies, and minored in Political Science.

Andrew Weisman is a Managing Partner and Chief Investment Strategist of Windham Capital Management, LLC. Prior to joining Windham, Andy was the Chief Investment Officer of Janus Capital's Liquid Alternative Group. Prior to joining Janus Capital, he was Managing Director and Chief Portfolio Manager for the Merrill Lynch Hedge Fund Development and Management Group, and Chief Investment Officer for Nikko Securities International. Andy has a Masters in International Affairs/International Business from Columbia University's School of International and Public Affairs, and a BS in Philosophy/Economics from Columbia University and has completed all of the course work and comprehensive exams toward a PhD from Columbia University's Graduate School of Business. He is a recipient of the Bernstein Fabozzi /Jacobs Levy Award for outstanding article published in the *Journal of Portfolio Management* and the Roger F Murray Prize (First Place) awarded by the Institute for Quantitative Research in Finance. He is on the board of the International Association for Quantitative Finance, the Board of The Institute for Quantitative Research, and the Editorial Advisory Board of the *Journal of Portfolio Management*. He served for three years as President of the Society of Columbia Graduates.

