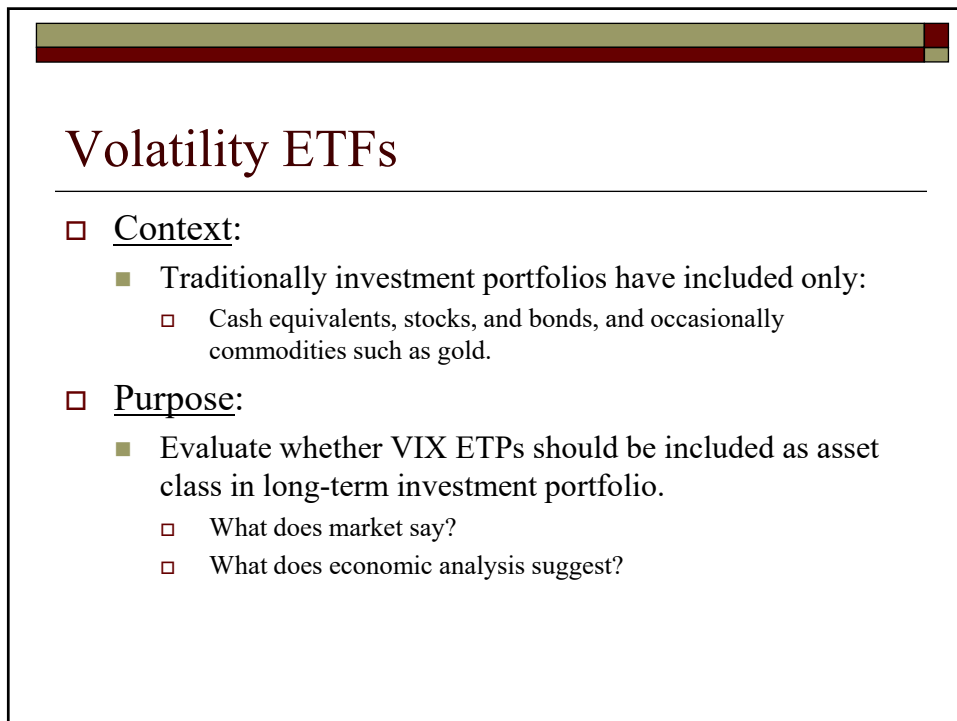


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2

Volatility ETFs

□ Outline:

- Explain origin of VIX.
- What is VIX in theory?
- What is VIX in reality?
- How are VIX and SPX related?
- What are normal levels of VIX through history?
- When were VIX futures and options launched?
- Should VIX ETPs be included in long-term investment portfolios?

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Origin of VIX

□ Who created VIX? Me

- In the fall of 1992, CBOE asked me to create stock market volatility index based on prices of S&P index options.
- Motives for creating VIX:
 - Public relations: Real-time index of expected stock market volatility.
 - Financial: Reference asset to possibly serve as underlying for VIX futures and options.
 - Digression: Uncertainty has been resolved. VIX futures and options market have been enormously successful currently account for about 40% of CBOE annual revenue, none of which is shared with me.

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Origin of VIX

- Where was VIX created? France



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Origin of VIX

- Where was VIX created? Aunay-en-Bazois



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Origin of VIX

- Where was VIX created? Birthplace



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Origin of VIX

- Why Aunay-en-Bazois? View from backyard



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Origin of VIX

- Trivia fact:
 - Who chose ticker symbol?
 - CBOE originally chose “REW.”
 - Found symbol had been reserved by AMEX.
 - CBOE then faxed me available symbols.
 - I chose “VIX.”

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What is VIX in theory?

- VIX is implied volatility from S&P 500 index option prices.
 - Its theoretical definition is, therefore, expected stock market volatility over next 30 days expressed on annualized basis.

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What is VIX in reality?

- VIX is price of stock market insurance.
 - Fear about stock market downturn causes institutions to buy portfolio insurance (S&P 500 index puts).
 - Buying pressure causes index put prices (implied volatilities) to rise.
 - VIX is weighted average of prices of index options (different stock portfolio insurance policies).
 - I dubbed it “market fear gauge.”

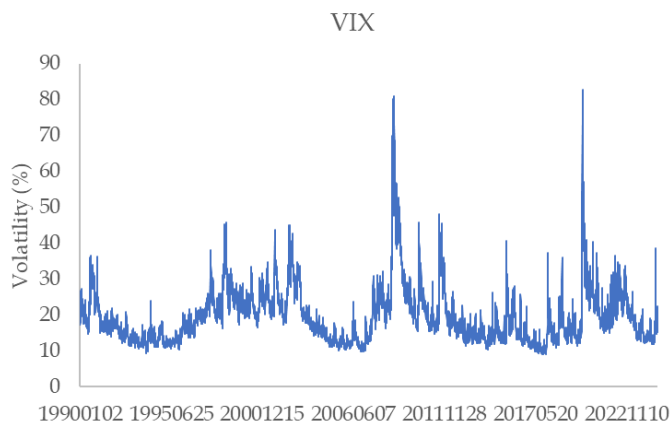
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How are VIX and SPX related?

- Downloaded daily VIX and S&P 500 total return index from Bloomberg.
- Sample period: 19900102 through 20240930
- No. of obs.: 8,753
- Support file: VIX SPX histories and analyses.xlsx
(Sheets: (a) Entire histories and (b)Relation between VIX and SPX)

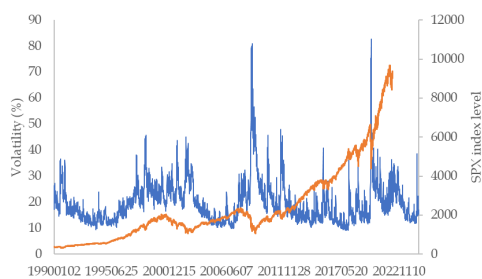
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What are historical levels of VIX?



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What is relation of VIX with SPX?



Observations:

- 1) VIX is 0. VIX has mean reversion.
- 2) VIX is 5 times more volatile than SPX.
- 3) VIX and SPX have strong negative correlation.

Summary

Description	VIX	SPX
No. of obs.	8752	8752
Mean (daily)	-0.0003%	0.0398%
StDev (daily)	6.7174%	1.1397%
Skewness	0.977	-0.397
Kurtosis	6.497	10.653
Autocorrelation	-0.084	-0.079
Minimum	-35.06%	-12.76%
Median	-0.40%	0.07%
Maximum	76.82%	10.96%
Mean (annual)	-0.09%	10.03%
StDev (annual)	106.64%	18.09%
CAGR	-0.09%	10.55%
HPR	-2.96%	3153.67%

Correlations

	VIX	SPX
VIX	1	-0.708
SPX	-0.708	1

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What are normal levels for VIX?

VIX critical levels					
Description	1990-current	1990-1999	2000-2009	2010-2019	2020-current
<i>n</i>	8,753	2,528	2,514	2,517	1,194
Minimum	9.14	9.31	9.89	9.14	11.86
2.5%	10.80	11.21	10.81	10.03	12.46
5%	11.38	11.50	11.29	10.67	12.83
10%	12.09	12.03	12.02	11.67	13.45
25%	13.82	13.76	14.83	13.05	16.04
Median	17.62	17.11	20.64	15.47	22.24
75%	22.86	21.80	25.87	18.90	25.47
90%	28.73	26.47	33.11	24.00	30.63
95%	33.20	29.62	41.26	28.39	33.90
97.5%	39.20	32.41	47.86	32.92	40.90
Maximum	82.69	45.74	80.86	48.00	82.69
Mean	19.48	18.47	22.12	16.86	21.63
StDev	7.87	5.91	9.90	5.63	8.39
Skewness	2.18	1.13	1.86	1.76	2.48

Observations:

- Median = 17.62
- Mean = 19.48
- Minimum = 9.48
- Maximum = 82.69

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How should VIX be interpreted?

- ❑ In theory, VIX is expected S&P 500 stock market return volatility over next 30 days.
- ❑ In reality, VIX is price of short-term stock market portfolio insurance.
 - Fear about stock market downturn causes institutions to buy portfolio insurance (S&P 500 index puts).
 - Buying pressure causes index put prices (implied volatilities) to rise.
 - VIX is weighted average of prices of index options (different stock portfolio insurance policies).

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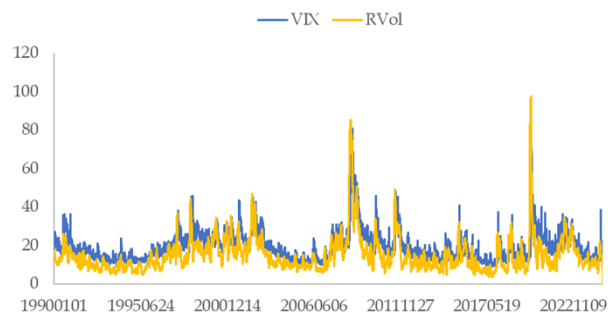
How should VIX be interpreted?

- Test hypothesis.
 - Support file: VIX SPX histories and analyses.xlsx.
 - Using return data, compute realized volatility over next 21 trading days.
 - Annualize volatility.
 - Take daily difference between VIX and realized volatility each day. Called volatility risk premium.
 - What should difference be on average?
 - Zero if VIX is accurate predictor of 30-day volatility.
 - Positive if VIX is price of portfolio insurance.

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VIX value is inflated

- Used daily data from 1990 through present.

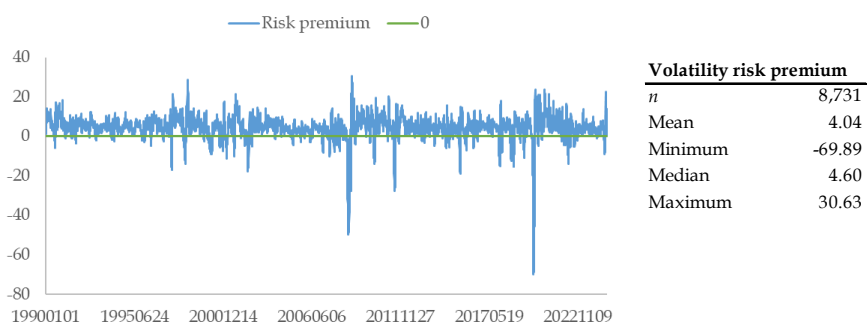


VIX is persistently higher than subsequently realized volatility.

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VIX value is inflated

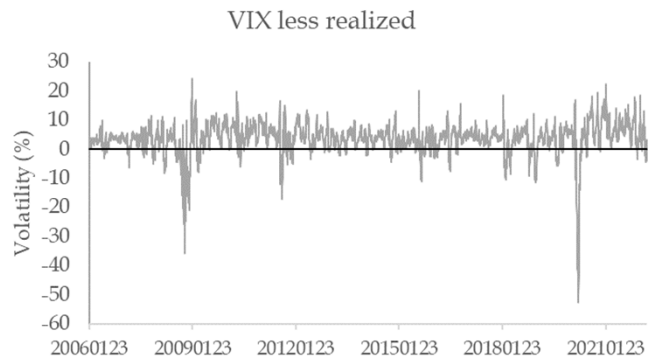
- Used daily data from 1990 through present.



Claims that VIX is estimate of expected stock market volatility over next 30 days are wrong.

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Difference between implied and realized



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Developing VIX as asset class

- First step in creating VIX ETPs was to develop VIX futures market.
 - VIX is not investable in cost-efficient manner, so first-generation replication ETPs is not possible.
 - Need to use fully collateralized futures position.
 - While VIX index has been reported on real-time basis since January 1993, VIX futures was not launched until March 2004 (10 years later).

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Phenomenal success (Ogilvy station)

- Markets have been spectacularly successful.
 - VIX futures now trade 24 hours a day.
 - VIX options often trade more than million contracts daily.



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VIX ETPs as asset class

- Next step was to structure VIX ETP using rolling 30-day VIX futures index.
 - Barclay's Bank launched ETN in January 2009.
 - Other volatility ETPs followed.
 - Source: ETFdb.com (20241229)

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SPVXSTR – Definition

- VIX futures index (SPVXSTR) has constant 30 days to expiration and is computed from uses prices of two nearby futures contracts.
 - Position is rolled each day from nearest month futures to next month futures in equal fractional amounts.
 - Results in one-month rolling long position.

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Should volatility be included as asset class?

- ❑ ETFdb.com misclassified some volatility ETPs.

Volatility ETPs with greater than \$100M in \$AUM as of 20231231					
Symbol	Name	Assets	Inception	ER	Days
FJUL	FT Cboe Vest U.S. Equity Buffer ETF - July	631	20200717	0.85%	127.4
SVOL	Simplify Volatility Premium ETF	588	20210512	0.50%	56.3
DJUL	FT Cboe Vest U.S. Equity Deep Buffer ETF - July	451	20200717	0.85%	90.6
FSEP	FT Cboe Vest U.S. Equity Buffer ETF - September	444	20200918	0.85%	191.4
UVXY	ProShares Ultra VIX Short-Term Futures ETF	346	20111003	0.95%	1.9
SVXY	ProShares Short VIX Short-Term Futures ETF	283	20111003	0.95%	1.4
VXX	iPath Series B S&P 500 VIX Short-Term Futures ETN	260	20180119	0.89%	1.6
DSEP	FT Cboe Vest U.S. Equity Deep Buffer ETF - September	195	20200918	0.85%	105.9
VIXY	ProShares VIX Short-Term Futures ETF	157	20110103	0.85%	2.7
SVIX	-1x Short VIX Futures ETF	137	20220328	1.47%	1.8

Are written on SPX not VIX. Do not belong.

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Should volatility be included as asset class?

- ❑ After eliminations, levered and inverse ETPs remain.

Volatility ETPs with greater than \$100M in \$AUM as of 20231231					
Symbol	Name	Assets	Inception	ER	Days
SVOL	Simplify Volatility Premium ETF	588	20210512	0.50%	56.3
UVXY	ProShares Ultra VIX Short-Term Futures ETF	346	20111003	0.95%	1.9
SVXY	ProShares Short VIX Short-Term Futures ETF	283	20111003	0.95%	1.4
VXX	iPath Series B S&P 500 VIX Short-Term Futures ETN	260	20180119	0.89%	1.6
VIXY	ProShares VIX Short-Term Futures ETF	157	20110103	0.85%	2.7
SVIX	-1x Short VIX Futures ETF	137	20220328	1.47%	1.8

Levered and inverse funds are inappropriate for long-term investment.

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Should volatility be included as asset class?

□ Remaining 1x ETPs

Volatility ETPs with greater than \$100M in \$AUM as of 20231231					
Symbol	Name	Assets	Inception	ER	Days
VXX	iPath Series B S&P 500 VIX Short-Term Futures ETN	260	20180119	0.89%	1.6
VIXY	ProShares VIX Short-Term Futures ETF	157	20110103	0.85%	2.7

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Diversification

□ Support file: VXX fact sheet

Market Indicators	
Closing Indicative Note Value	\$55.07
Market Capitalization	\$284,711,239
ETNs Outstanding	5,169,988
Summary	
Asset Class	Volatility
Primary Exchange	CBOE
Currency	USD
Fees	0.89% per annum
BBG Ticker	VXXIV
Execution Cost	None
ETN Ticker	VXX
Bloomberg Ticker	SPVXSTR
Cusip	06748M196
ISIN	US06748M1962
Inception Date	January 19, 2018
Maturity Date	January 23, 2048

Notes:

- VXX is ETN benchmarked to S&P 500 VIX short-term futures index (SPVXSTR).
- VXX was issued in 2018 and matures in 2048.
- VXX has highest \$AUM and greatest market liquidity of any 1x VIX ETPs.

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Diversification

□ Support file: VIXY fact sheet

Fund objective

ProShares VIX Short-Term Futures ETF seeks investment results, before fees and expenses, that match the performance of the S&P 500® VIX® Short-Term Futures Index™.

Notes:

- VIXY is ETF benchmarked to SPVXSP.
- VIXY was launched in 2011.

Fund details

Inception Date	1/3/11
Trading Symbol	VIXY
Intraday Symbol	VIXY.IV
Bloomberg Index Symbol	SPVXSPID
CUSIP	74347Y789
Exchange	Cboe BZX
Net Assets	\$148.42 million
Expense Ratio ¹	0.85%

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Compute summary statistics

□ Support file: VIX ETP evaluation.xlsx

- Step 1: Download total return index data for VIX, SPVXSTR, VXX, and VIXY.
- Step 2: Purge non-US trading days.
- Step 3: Compute summary statistics.
 - Go to Excel file.

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Summary statistics

Summary						
Description	EFFR	BND	VTI	IAU	VIX	SPVXSTR
No. of obs.	3,961	3,961	3,961	3,961	3,961	3,961
Mean (daily)	0.0045%	0.0104%	0.0532%	0.0267%	-0.0215%	-0.2915%
StDev (daily)	0.0082%	0.3061%	1.1545%	1.0021%	7.6027%	4.4542%
Skewness	3.379	-1.079	-0.609	-0.454	1.145	1.745
Kurtosis	13.797	40.943	10.257	4.434	6.613	18.739
Autocorrelator	0.564	-0.017	-0.090	-0.005	-0.079	-0.054
Minimum	0.00%	-5.59%	-12.08%	-9.26%	-35.06%	-30.05%
Median	0.00%	0.02%	0.08%	0.06%	-0.69%	-0.71%
Maximum	0.06%	4.13%	9.07%	4.83%	76.82%	67.35%
Mean (annual)	1.12%	2.63%	13.40%	6.72%	-5.42%	-73.46%
StDev (annual)	0.13%	4.86%	18.33%	15.91%	120.69%	70.71%
CAGR	1.13%	2.66%	14.34%	6.96%	-5.27%	-52.03%
HPR	19.34%	51.16%	721.75%	187.78%	-57.31%	-100.00%

VIX

- Mean return of -5.42%
- Volatility of 120.69%

SPVXSTR

- Mean return of -73.46%
- Volatility of 70.71%

Correlations						
	EFFR	BND	VTI	IAU	VIX	SPVXSTR
EFFR	1	-0.036	-0.007	0.007	0.057	0.015
BND	-0.036	1	-0.008	0.290	0.057	0.066
VTI	-0.007	-0.008	1	0.056	-0.738	-0.742
IAU	0.007	0.290	0.056	1	-0.026	-0.024
VIX	0.057	0.057	-0.738	-0.026	1	0.901
SPVXSTR	0.015	0.066	-0.742	-0.024	0.901	1

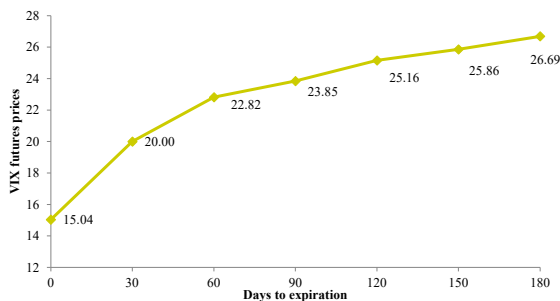
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Why are VIX futures index returns negative?

□ Keynes (1930)

- VIX futures curve is typically in contango.
 - More long hedgers than short hedgers.
- VIX futures price exceeds expected volatility by risk premium.

Typical day:
March 19, 2012



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Set asset category parameters

Expected returns and expected volatility						
Description	EFFR	BND	VTI	IAU	VIX	SPVXSTR
Mean (annual)	1.12%	2.63%	13.40%	6.72%	-5.42%	-73.46%
StDev (annual)	0.13%	4.86%	18.33%	15.91%	120.69%	70.71%

Expected correlations						
	EFFR	BND	VTI	IAU	VIX	SPVXSTR
EFFR	1	-0.036	-0.007	0.007	0.057	0.015
BND	-0.036	1	-0.008	0.290	0.057	0.066
VTI	-0.007	-0.008	1	0.056	-0.738	-0.742
IAU	0.007	0.290	0.056	1	-0.026	-0.024
VIX	0.057	0.057	-0.738	-0.026	1	0.901
SPVXSTR	0.015	0.066	-0.742	-0.024	0.901	1

Expected returns						
	EFFR	BND	VTI	IAU	VIX	SPVXSTR
Nominal rate	4.83%	4.61%	6.44%	5.02%		
E(ln return)	4.72%	4.51%	6.24%	4.90%	0.00%	-73.46%

VIX follows a mean-reverting process. The best estimate of its expected return is 0%.

SPVXSTR's expected return is negative because of the persistent contango in the VIX futures market. Using its historical level, -73.46%, as a proxy for expected return is not unreasonable.

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Include VIX.

Portfolio allocations at different risk tolerances							
Expected return	Expected volatility	Optimal portfolio weights					
		EFFR	BND	VTI	IAU	VIX	SPVXSTR
4.76%	0.50%	0.9613	0.0000	0.0346	0.0020	0.0021	0.0000
4.81%	1.00%	0.9202	0.0000	0.0713	0.0041	0.0044	0.0000
4.99%	3.00%	0.7576	0.0000	0.2163	0.0127	0.0134	0.0000
5.17%	5.00%	0.5996	0.0000	0.3589	0.0197	0.0217	0.0000
5.39%	7.50%	0.3975	0.0000	0.5428	0.0258	0.0339	0.0000
5.61%	10.00%	0.1805	0.0000	0.7216	0.0528	0.0451	0.0000
5.84%	12.50%	0.0000	0.0000	0.9016	0.0429	0.0554	0.0000
6.24%	18.30%	0.0000	0.0000	0.9997	0.0000	0.0003	0.0000
5.21%	25.00%	0.0000	0.0000	0.7254	0.0000	0.2746	0.0000

Constrained SPVXSTR allocation to 0 in Solver.

If VIX, in fact, did trade as as ETP, modest allocations are optimal.

Problem is that VIX is that it does not.

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Include SPVXSTR instead.

Portfolio allocations at different risk tolerances							
Expected return	Expected volatility	Optimal portfolio weights					
		EFFR	BND	VTI	IAU	VIX	SPVXSTR
4.76%	0.50%	0.9712	0.0000	0.0262	0.0026	0.0000	0.0000
4.80%	1.00%	0.9413	0.0000	0.0538	0.0049	0.0000	0.0000
4.97%	3.00%	0.8207	0.0000	0.1622	0.0171	0.0000	0.0000
5.13%	5.00%	0.6995	0.0000	0.2701	0.0304	0.0000	0.0000
5.34%	7.50%	0.5548	0.0000	0.4059	0.0393	0.0000	0.0000
5.55%	10.00%	0.4042	0.0000	0.5409	0.0548	0.0000	0.0000
5.76%	12.50%	0.2575	0.0000	0.6764	0.0661	0.0000	0.0000
6.24%	18.30%	0.0000	0.0000	0.9984	0.0016	0.0000	0.0000

Constrained VIX allocation to 0 in Solver.

At no level of risk tolerance is investment in SPVXSTR sensible.

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Who are they kidding?



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Should volatility be included as asset class?

- ❑ Economic analysis says “no.”
- ❑ What does market say? (Source: ETFdb.com)

Volatility ETPs with greater than \$100M in \$AUM as of 20231231					
Symbol	Name	Assets	Inception	ER	Days
VXX	iPath Series B S&P 500 VIX Short-Term Futures ETN	260	20180119	0.89%	1.6
VIXY	ProShares VIX Short-Term Futures ETF	157	20110103	0.85%	2.7

- Says “no” too. \$AUM
- \$AUM are trivial.
 - Turnover is high. Holding periods are about 2 days.
 - Primary use is day-trading.

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Lesson summary

- ❑ VIX is upward-biased estimator of expected stock market volatility of next 30 days.
 - Excess demand from institutions for buying index puts during times of market stress drives implied volatility (and hence VIX) upward.

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Lesson summary

- VIX ETPs can only be futures-based because VIX is not investable.
 - Futures-based products are non-starters as long-term investments because VIX futures market is typically in contango.
 - Investors want VIX.
 - Day-traders dominate VIX ETP market.

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