

Incorporating a Minimum Variance Framework into Risk Control 2

Contributors

Cristopher Anguiano, FRM
Senior Analyst
Global Research & Design
cristopher.anguiano@spglobal.com

Laura Assis Iragorri
Analyst
Global Research & Design
laura.assis@spglobal.com

Gaurav Sinha
Managing Director, Head of Americas
Global Research & Design
gaurav.sinha@spglobal.com

INTRODUCTION

In this paper, we introduce the new [S&P 500® Futures Daily Risk Control 5% Index](#) (the Risk Control 2 Minimum Variance), which is the latest enhancement to S&P DJI's Risk Control 1 (RC 1) and Risk Control 2 (RC 2), and a variation on our existing standard RC 2 methodology.¹

Our risk control techniques began with RC 1, which allocates to equity and cash to achieve a target volatility. RC 2 then introduced fixed income as another asset class and allocates between an equity and liquid bond index to target a specific volatility. The bond sleeve in RC 2 is generally a risk reduction tool. However, in volatile periods when no suitable combination of equity and fixed income is able to attain the target volatility, RC 2 rotates its bond sleeve completely to cash, thereby defaulting to RC 1.

In this new index, we take RC 2 a step further, to RC 2 Minimum Variance. We allocate to equity and bonds like RC 2; however, unlike RC 2, we introduce cash as an extra alternative rather than a complete swap when underlying volatility picks up.

Exhibit 1: S&P DJI's Suite of Risk Control Approaches

APPROACH	SCENARIO	ALLOCATION
Risk Control 1	Risk On	Equity-Cash
	Risk Off	Equity-Cash
Risk Control 2	Risk On	Equity-Bonds
	Risk Off	Equity-Cash
Risk Control 2 Minimum Variance	Risk On	Equity-Bonds
	Risk Off	Equity-Bonds-Cash

Source: S&P Dow Jones Indices LLC. Table is provided for illustrative purposes.

¹ The hypothetical portfolios follow the standard S&P DJI Risk Control 1 and 2 methodology, using the same inputs as the S&P 500 Futures Daily Risk Control 5% Index outlined in the Index Components and Characteristics section. Henceforth, we will use RC 1 to refer to the hypothetical S&P 500 Futures Risk Control 1 5%, RC 2 to refer to the hypothetical S&P 500 Futures Risk Control 2 5%, and RC 2 Minimum Variance to refer to the S&P 500 Futures Daily Risk Control 5% Index.

WHY A NEWER VERSION OF RC 2?

S&P DJI introduced the Risk Control 2 Minimum Variance, a new strategy to join Risk Control 1 and 2 approaches.

Though RC 2 takes the RC 1 approach a notch higher by introducing bonds, it still has one shortcoming. In instances when the volatility target is relatively too low (i.e., during periods of sell-off), the bond sleeve of RC 2 switches completely to cash.

While allocating to cash reduces index volatility, thus bringing it in line with the target, this comes at a cost of higher turnover resulting from this bond-to-cash swap. Our new optimized approach addresses this problem through its innovative technique and significantly reduces turnover.

HOW THE INDEX WORKS

Index Approach

While RC 2 took RC 1 a notch higher by introducing bonds, when the volatility target is relatively too low, the bond sleeve switches to cash.

The RC 2 framework's objective is to find a suitable combination for equity and fixed income weights to reach a target volatility (σ_{Target}). If we assume the portfolio variance has no real solution for an equity index and its corresponding bond index, we can find a closed solution for minimum weights, instead of defaulting to RC 1.

If such a solution exists, it means that the minimum volatility achievable must be below the target volatility. In the case when the target volatility is not achievable, the minimum volatility must be higher than the target volatility. Therefore, the allocation to each asset class can be rescaled to reach the target volatility but, in doing so, a cash position is required. The S&P 500 Futures Daily Risk Control 5% Index uses this alternative approach, RC 2 Minimum Variance.

RC 2 Minimum Variance addresses this problem through its innovative technique and significantly reduces turnover.

Let us define a function $f(x)$ that represents the index portfolio variance, where x is the risky asset 1 weight (note that the election of the risky asset does not affect the solution):

$$f(x) = x^2 \sigma_1^2 + (1 - x)^2 \sigma_2^2 + 2x(1 - x)\rho\sigma_1\sigma_2,$$

where σ_i is the volatility of risky asset i , and ρ is the correlation. By differentiating function f , we get:

$$\frac{df}{dx} = 2x(\sigma_1^2 + \sigma_2^2 - 2\rho\sigma_1\sigma_2) + 2\rho\sigma_1\sigma_2 - 2\sigma_2^2.$$

By equating the first derivative to zero, we obtain:

$$x^* = \frac{\sigma_2^2 - \rho\sigma_1\sigma_2}{\sigma_1^2 + \sigma_2^2 - 2\rho\sigma_1\sigma_2}.$$

To determine if this is a local minimum or maximum, the second order derivative must be calculated:

If we assume the portfolio variance has no real solution for the equity and bond indices, we can find a closed solution for minimum weights, instead of defaulting to RC 1.

$$\frac{d^2 f}{dx^2} = 2(\sigma_1^2 + \sigma_2^2 - 2\rho\sigma_1\sigma_2) \geq 2(\sigma_1 - \sigma_2)^2.$$

The right side of the inequality is always greater than or equal to zero, so x^* is a local minimum. It is not hard to see that the first derivative as a function of x is a monotonically increasing function; hence, the portfolio index variance is a convex function. The main consequence is that x^* is a global minimum for all x in $0 \leq x \leq 1$.

Given that the risky asset weights must sum to 1, the minimum portfolio index variance weights are:

$$x_1^{Min} = \frac{\sigma_2^2 - \rho\sigma_1\sigma_2}{\sigma_1^2 + \sigma_2^2 - 2\rho\sigma_1\sigma_2}$$

$$x_2^{Min} = 1 - x_1^{Min}.$$

If such a solution exists, it means that the minimum volatility must be below the target and when the target volatility is not achievable, the minimum must be higher than the target volatility.

However, portfolio index volatility is still higher than the target volatility if we use the minimum weights. Hence, risky asset weights are rescaled by multiplying each one to a scalar factor $\theta < 1$ to reach the target volatility, defined as:

$$\theta = \frac{\sigma_{Target}}{\sigma_{Min}}.$$

Then, the weight of risky asset i is:

$$x_i = \theta x_i^{Min}.$$

To get 100% allocation, the cash position is:

$$x_{Cash} = 1 - (x_1 + x_2).$$

Therefore, the allocation to each asset class can be rescaled to reach the target volatility but, in doing so, a cash position is required.

Index Components and Characteristics

For RC 2 Minimum Variance, the underlying index components are:

- [S&P 500 Futures Index \(ER\)](#) as the equity component;
- [S&P 10-Year U.S. Treasury Note Futures Index \(ER\)](#) as the fixed income component; and
- Cash constituent.

As explained in the introduction, the index can allocate to the three underlying components simultaneously. The index parameters are:

The Risk Control 2 Minimum Variance consists of three components: the S&P 500 Futures, S&P 10-Year U.S. Treasury Note Futures Index, and cash.

- Target volatility of 5%;
- The Overnight USD LIBOR as the interest rate;
- Short-term volatility decay factor of 94%;
- Long-term volatility decay factor of 97%; and
- Daily limit allocation change of 15% for the equity and fixed income component.

The resulting index is an excess return version. However, note that by adding back the accrued interest to the excess returns, it will be a total return index.

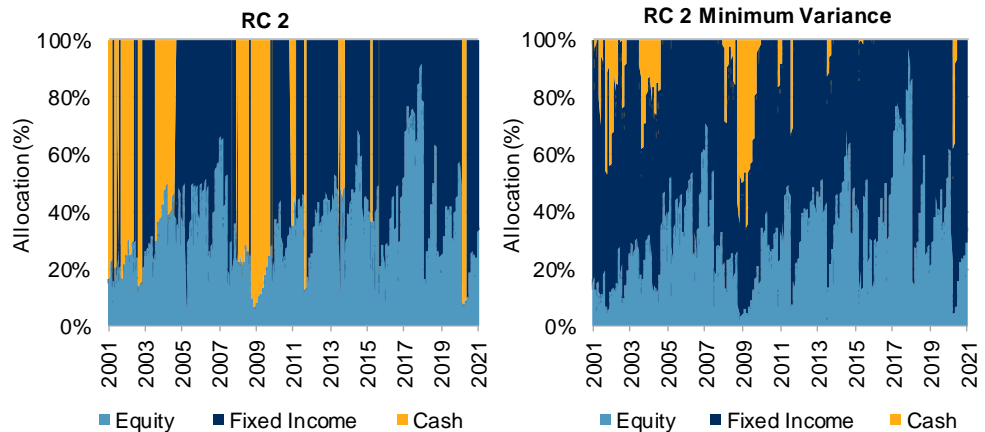
Turnover Comparison

As previously stated, one of the limitations of the RC 2 strategy is the high turnover due to the strong shift between the fixed income and cash components in situations when the strategy cannot reach the target volatility. Exhibit 1 shows the historical allocations for the RC 2 and RC 2 Minimum Variance strategies, and we can see that one of the main differences is the presence of three underlying components for the latter instead of only two at a time in the former.

One of the main differences between the RC2 and RC 2 Minimum Variance strategies is the presence of three underlying components for the latter, rather than two for the former.

In addition, each component gradually increases or decreases instead of completely changing from one day to the next. In highly volatile periods, like the Global Financial Crisis or the start of the COVID-19 pandemic, this effect was exacerbated. While the turnover reduction is enhanced by the requirement of 15% daily limit allocation change, RC 2 Minimum Variance reduces turnover without it.

Exhibit 1: Historical Asset Allocation for RC 2 and RC 2 Minimum Variance



Additionally, each component gradually increases or decreases instead of completely changing from one day to the next, resulting in lower turnover.

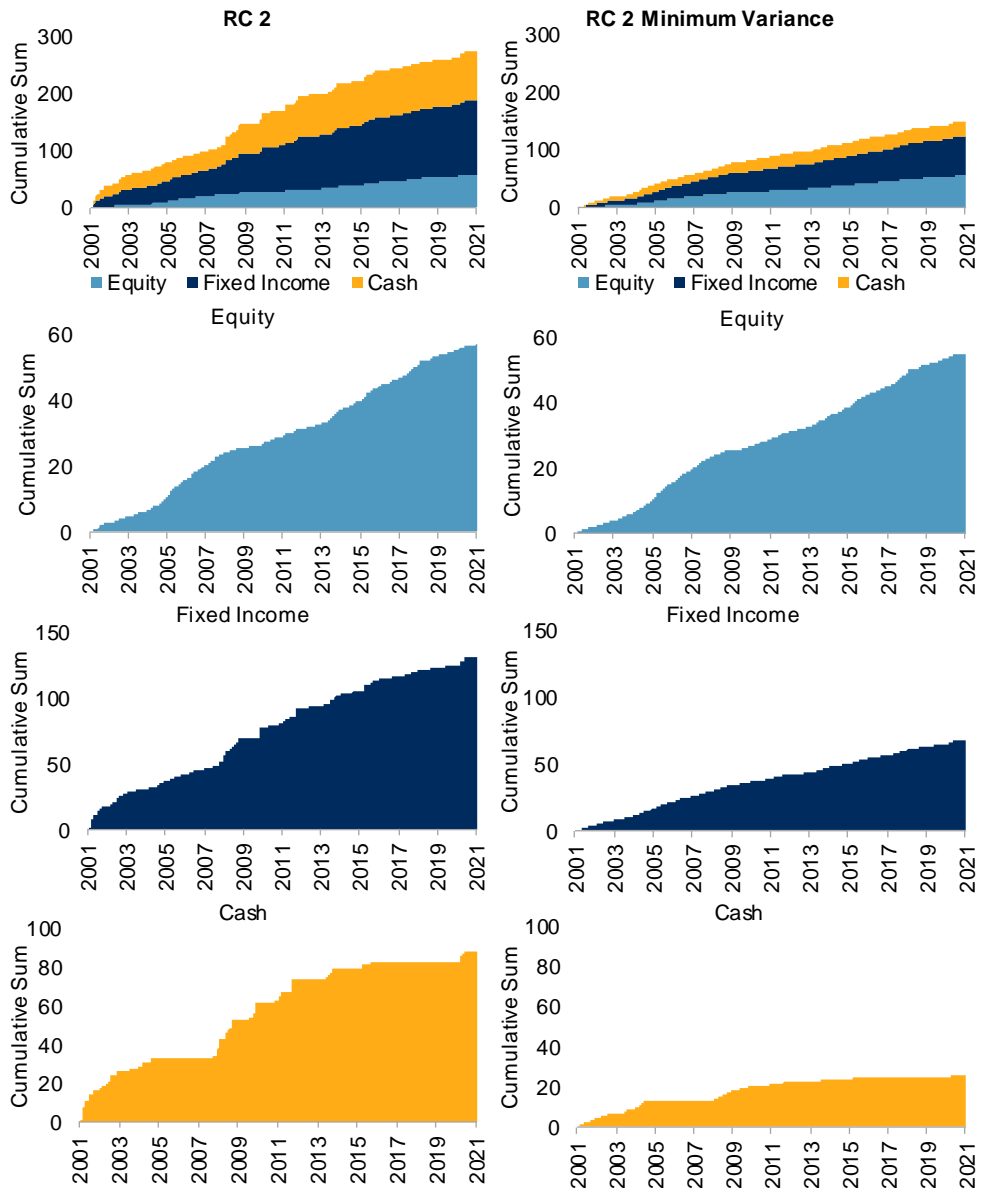
RC 2 is a hypothetical portfolio and RC 2 Minimum Variance represents the S&P 500 Futures Daily Risk Control 5% Index.

Source: S&P Dow Jones Indices LLC. Data from Jan. 2, 2001, to Jan. 29, 2021. Charts are provided for illustrative purposes and reflect hypothetical historical performance. Please see the Performance Disclosure at the end of this document for more information regarding the inherent limitations associated with back-tested performance.

On average, the equity allocation was similar for both approaches (36.4% in RC 2 and 33.5% in RC 2 Minimum Variance), while the fixed income allocation increased (from 45.1% in RC 2 to 60.8% in RC 2 Minimum Variance), and the cash allocation decreased (18.4% in RC 2 to 5.7% in RC 2 Minimum Variance). Further, we can see a significant reduction in trading volume if we calculate the cumulative sum of absolute daily differences in allocation for each underlying component (see Exhibit 2). As expected, the equity component changed slightly, and the main differences came from the fixed income and cash components.

On average, the equity allocation was similar for both approaches...

Exhibit 2: Cumulative Sum of Absolute Differences in Allocation



...while the fixed income allocation increased and the cash allocation decreased with the minimum variance strategy.

Further, we can see a significant reduction in trading volume if we calculate the cumulative sum of absolute daily differences in allocation for each underlying component.

RC 2 is a hypothetical portfolio and RC 2 Minimum Variance represents the S&P 500 Futures Daily Risk Control 5% Index.

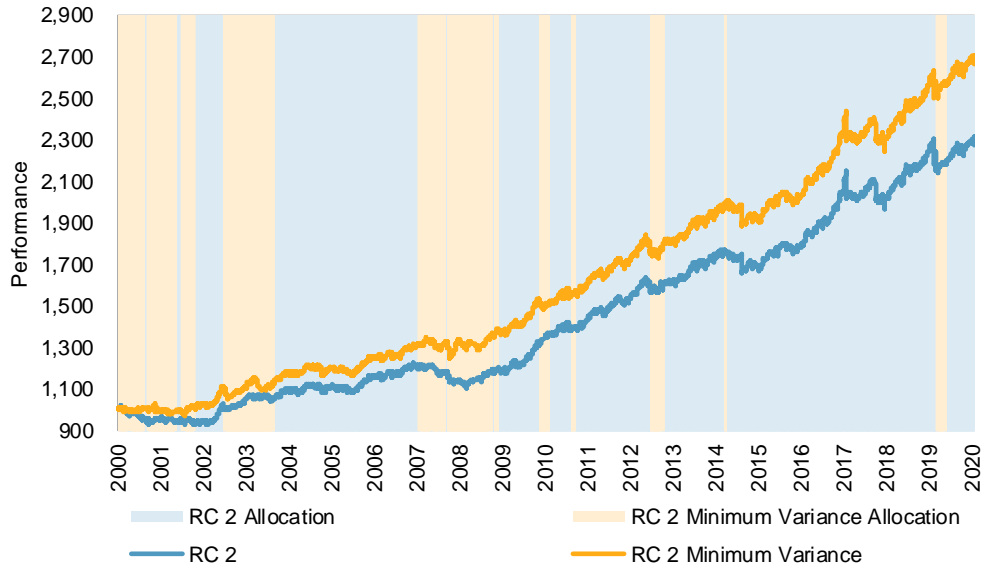
Source: S&P Dow Jones Indices LLC. Data from Jan. 2, 2001, to Jan. 29, 2021. Charts are provided for illustrative purposes and reflect hypothetical historical performance. Please see the Performance Disclosure at the end of this document for more information regarding the inherent limitations associated with back-tested performance.

Maintaining target volatility for RC 2 can be challenging during volatile periods, leading to the bond sleeve rotating to cash and thus generating more turnover.

Maintaining target volatility under the RC 2 framework can be challenging during volatile periods for equities and bonds, leading to the bond sleeve rotating to cash and thus generating more turnover.

Exhibit 3 shows how the two approaches differed. The majority of the time, the two approaches had the exact same allocation, but not during sell-off periods.

Exhibit 3: Historical Shifts between RC 2 and RC 2 Minimum Variance



RC 2 is a hypothetical portfolio and RC 2 Minimum Variance represents the S&P 500 Futures Daily Risk Control 5% Index.

Source: S&P Dow Jones Indices LLC. Data from Jan. 2, 2001, to Jan. 29, 2021. Index performance based on excess returns in USD. Chart is provided for illustrative purposes and reflects hypothetical historical performance. Please see the Performance Disclosure at the end of this document for more information regarding the inherent limitations associated with back-tested performance.

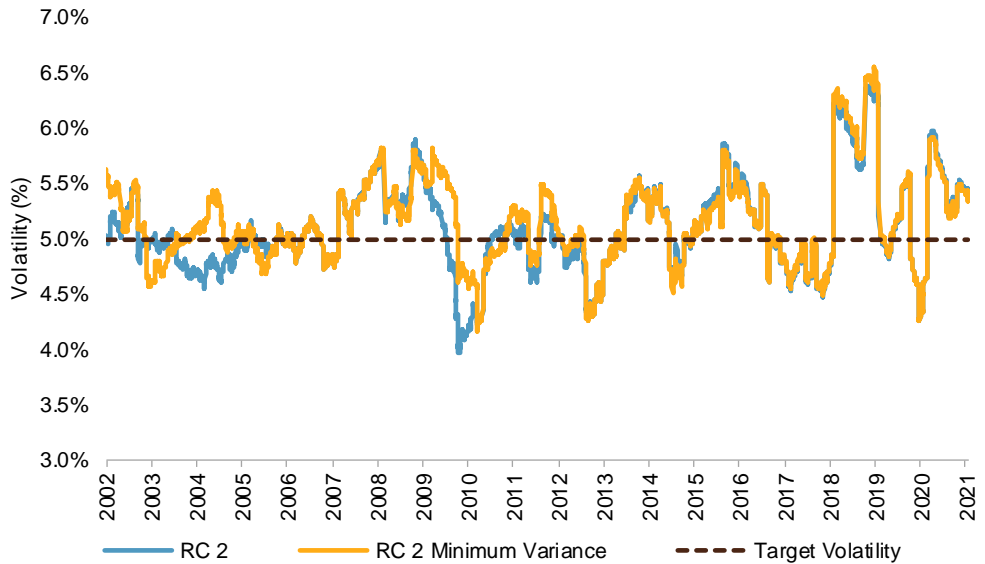
Though a majority of the time, the two approaches had the exact same allocation, they differed during sell-off periods.

In periods when the strategies differ, the annualized rolling volatility deviated between models but was still close to the desired target volatility level of 5%. These variations can be seen most clearly after the Tech Bubble (early 2000s), the Energy Crisis (starting 2003), and the Global Financial Crisis (starting 2007) in Exhibit 4.

On average, RC 2 had a 5.1% rolling volatility, similar to the 5.2% rolling volatility of RC 2 Minimum Variance. However, RC 2 Minimum Variance consistently maintained a lower turnover by reducing allocations gradually instead of completely shifting from fixed income to cash or vice versa.

In periods of high volatility such as the Global Financial Crisis (2007), the annualized rolling volatilities deviated between models but was still close to the desired target volatility of 5%.

Exhibit 4: Historical Annualized Rolling Volatilities



On average, RC 2 had a 5.1% rolling volatility, similar to the 5.2% rolling volatility of RC 2 Minimum Variance.

RC 2 is a hypothetical portfolio and RC 2 Minimum Variance represents the S&P 500 Futures Daily Risk Control 5% Index.

Source: S&P Dow Jones Indices LLC. Data from Jan. 3, 2002, to Jan. 29, 2021. Volatility is calculated as the standard deviation of daily excess returns over the previous 252 trading days that is annualized. Chart is provided for illustrative purposes and reflects hypothetical historical performance. Please see the Performance Disclosure at the end of this document for more information regarding the inherent limitations associated with back-tested performance.

Index Performance

RC 2 Minimum Variance historically showed more stable volatility control, lower drawdowns, and better risk-adjusted performance than the other risk control strategies. Like the risk control framework, the index provided downside protection and upside participation.

Downside Protection and Upside Participation

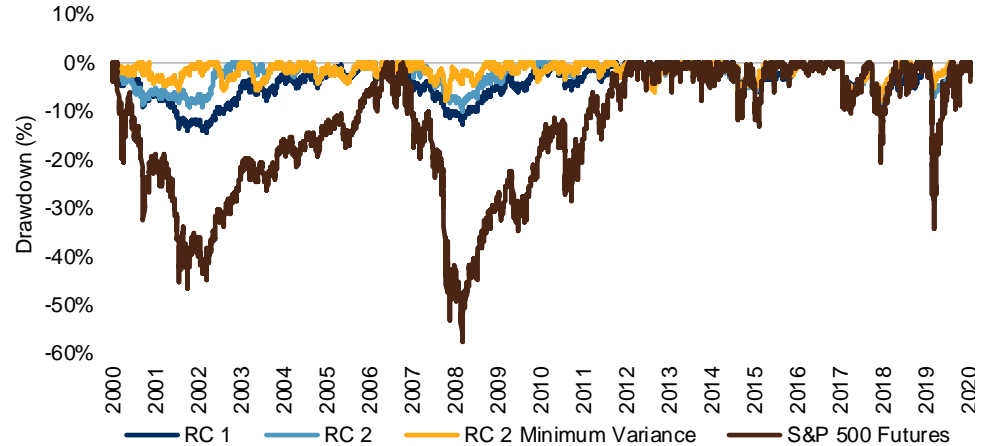
Focusing on the three worst drawdowns of the S&P 500 Futures in its recent history (i.e., the Global Financial Crisis, the Tech Bubble and the start of the COVID-19 pandemic), we analyzed the behavior of the RC 1, RC 2, and RC 2 Minimum Variance strategies. Not only did RC 2 Minimum Variance beat the benchmark but its peers as well (see Exhibits 5 and 6).

RC 2 Minimum Variance historically showed more stable volatility control, lower drawdowns, and better risk-adjusted performance than the other risk control strategies.

- **Global Financial Crisis:** The benchmark drawdown was -57.57%, while RC 2 Minimum Variance declined a mere 0.30%, with an excess of 57.27% and a peak-to-recovery return of 34.36%.
- **Tech Bubble:** The benchmark drawdown was -46.44%, whereas RC 2 Minimum Variance only declined 6 bps, with an excess of 46.38% and a peak-to-recovery return of 25.69%.
- **Start of the COVID-19 Pandemic:** The benchmark drawdown was -34.15%, while RC 2 Minimum Variance only declined only 3.99%, with an excess of 30.16% and a peak-to-recovery return of 0.02%.

Focusing on the three worst drawdowns of the S&P 500 Futures, we analyzed the behavior of the RC 1, RC 2, and RC 2 Minimum Variance strategies.

Exhibit 5: Historical Index Drawdowns



RC 1 and RC 2 are hypothetical portfolios and RC 2 Minimum Variance represents the S&P 500 Futures Daily Risk Control 5% Index.

Source: S&P Dow Jones Indices LLC. Data from Dec. 29, 2000, to Jan. 29, 2021. Index performance based on excess returns in USD. Past performance is no guarantee of future results. Drawdown is calculated as cumulative return since the most recent high-water mark. Chart is provided for illustrative purposes and reflects hypothetical historical performance. Please see the Performance Disclosure at the end of this document for more information regarding the inherent limitations associated with back-tested performance.

Not only did RC 2 Minimum Variance beat the benchmark but its peers as well.

Exhibit 6: Three Worst Drawdown Periods of the S&P 500 Futures

METRIC	THREE WORST DRAWDOWN PERIODS		
	FIRST: GLOBAL FINANCIAL CRISIS	SECOND: TECH BUBBLE	THIRD: COVID-19 PANDEMIC
PERIOD			
Peak Date	Oct. 9, 2007	Feb. 1, 2001	Feb. 19, 2020
Trough Date	March 9, 2009	Oct. 9, 2002	March 23, 2020
Recovery Date	Jan. 22, 2013	June 1, 2007	Aug. 12, 2020
S&P 500 FUTURES (BENCHMARK)			
Return (%)	-57.57	-46.44	-34.15
RC 1			
Return (%)	-12.16	-14.03	-6.80
Versus Benchmark (%)	45.41	32.41	27.35
Peak-to-Recovery Return (%)	5.24	4.70	-2.73
RC 2			
Return (%)	-8.27	-8.59	-6.85
Versus Benchmark (%)	49.30	37.85	27.31
Peak-to-Recovery Return (%)	29.20	15.90	-2.41
RC 2 MINIMUM VARIANCE			
Return (%)	-0.30	-0.06	-3.99
Versus Benchmark (%)	57.27	46.38	30.16
Peak-to-Recovery Return (%)	34.36	25.69	0.02

RC 1 and RC 2 are hypothetical portfolios and RC 2 Minimum Variance represents the S&P 500 Futures Daily Risk Control 5% Index.

Source: S&P Dow Jones Indices LLC. Data from Dec. 29, 2000, to Jan. 29, 2021. Index performance based on excess returns in USD. Past performance is no guarantee of future results. Table is provided for illustrative purposes and reflects hypothetical historical performance. Please see the Performance Disclosure at the end of this document for more information regarding the inherent limitations associated with back-tested performance.

During the Global Financial Crisis, the benchmark drawdown was -57.57%, while RC 2 Minimum Variance declined a mere 0.30%.

Both RC 2 and RC 2 Minimum Variance provided at least a 90% outperformance rate in down markets without losing participation in up markets.

RC 2 and RC 2 Minimum Variance offered similar outperformance rates in up and down markets, as expected. Both indices provided at least a 90% outperformance rate in down markets without losing participation in up markets, with 7.6% and 10.0% outperformance rates for RC 2 and RC 2 Minimum Variance, respectively. Over all periods, the outperformance rates and average daily excess returns of RC 2 Minimum Variance were slightly higher than the other strategies as shown in Exhibit 7.

Exhibit 7: Performance in Up and Down Markets

METRIC	UP MARKETS	DOWN MARKETS	ALL PERIODS
RC 1			
Average Daily Excess Return (%)	-0.545	0.619	-0.019
Outperformance Rate (%)	0.000	100.000	45.157
RC 2			
Average Daily Excess Return (%)	-0.568	0.664	-0.011
Outperformance Rate (%)	7.569	92.007	46.280
RC 2 MINIMUM VARIANCE			
Average Daily Excess Return (%)	-0.600	0.711	-0.008
Outperformance Rate (%)	10.055	90.098	46.922

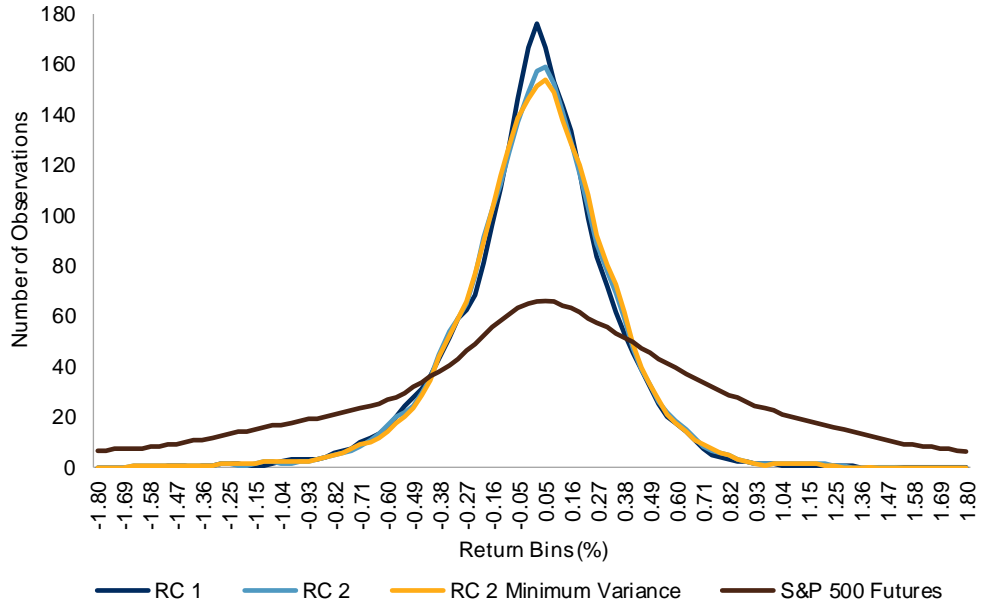
Over all periods, the outperformance rates and average daily excess returns of RC 2 Minimum Variance were slightly higher than the other strategies.

RC 1 and RC 2 are hypothetical portfolios and RC 2 Minimum Variance represents the S&P 500 Futures Daily Risk Control 5% Index. Source: S&P Dow Jones Indices LLC. Data from Dec. 29, 2000, to Jan. 29, 2021. Index performance based on excess returns in USD. Past performance is no guarantee of future results. Table is provided for illustrative purposes and reflects hypothetical historical performance. Please see the Performance Disclosure at the end of this document for more information regarding the inherent limitations associated with back-tested performance.

Exhibit 8 shows the return distribution of the S&P 500 Futures, RC 1, RC 2, and RC 2 Minimum Variance. The presence of fat tails in the S&P 500 Futures return distribution is expected; however, we can see that each of the risk control indices addresses this issue by effectively managing volatility. Moreover, historically, the RC 2 alternatives have lower peaks around the mean and have a slight left skew, meaning a slightly higher probability of delivering positive returns.

The presence of fat tails in the S&P 500 Futures return distribution is expected...

Exhibit 8: Return Distributions



...however, we can see that each of the risk control indices addresses this issue by effectively managing volatility.

RC 1 and RC 2 are hypothetical portfolios and RC 2 Minimum Variance represents the S&P 500 Futures Daily Risk Control 5% Index.
 Source: S&P Dow Jones Indices LLC. Data from Dec. 29, 2000, to Jan. 29, 2021. Index performance based on excess returns in USD. Past performance is no guarantee of future results. Chart is provided for illustrative purposes and reflects hypothetical historical performance. Please see the Performance Disclosure at the end of this document for more information regarding the inherent limitations associated with back-tested performance.

Risk/Return Profile

As seen in Exhibit 9, the S&P 500 Futures Daily Risk Control 5% Index outperformed the S&P 500 Futures and its risk control peers in terms of risk-adjusted returns while maintaining a stable volatility level for all analysis periods. The annualized volatility level is slightly higher than the other risk control versions, but this is compensated with a higher annualized return.

The S&P 500 Futures Daily Risk Control 5% Index outperformed the S&P 500 Futures and its risk control peers in terms of risk-adjusted returns...

...while maintaining a stable volatility level for all analysis periods.

Exhibit 9: Risk-Adjusted Returns				
PERIOD	RC 1	RC 2	RC 2 MINIMUM VARIANCE	S&P 500 FUTURES
ANNUALIZED RETURN (%)				
YTD	1.59	2.06	4.59	16.22
1-Year	1.67	1.20	3.71	16.47
3-Year	0.56	2.44	3.45	9.53
5-Year	4.69	6.03	6.65	14.36
7-Year	3.55	5.10	5.75	11.88
10-Year	3.62	5.31	5.86	12.31
Cumulative	2.08	4.19	5.01	5.21
ANNUALIZED VOLATILITY (%)				
3-Year	5.35	5.43	5.46	22.97
5-Year	5.14	5.19	5.21	18.73
7-Year	5.16	5.23	5.24	17.58
10-Year	5.10	5.17	5.18	17.37
Cumulative	5.01	5.09	5.16	19.75
RETURN/RISK				
3-Year	0.10	0.45	0.63	0.42
5-Year	0.91	1.16	1.28	0.77
7-Year	0.69	0.97	1.10	0.68
10-Year	0.71	1.03	1.13	0.71
Cumulative	0.41	0.82	0.97	0.26
ANNUALIZED SKEWNESS				
Cumulative	-0.055	-0.043	-0.043	0.002
ANNUALIZED EXCESS KURTOSIS				
Cumulative	0.022	0.019	0.020	0.053

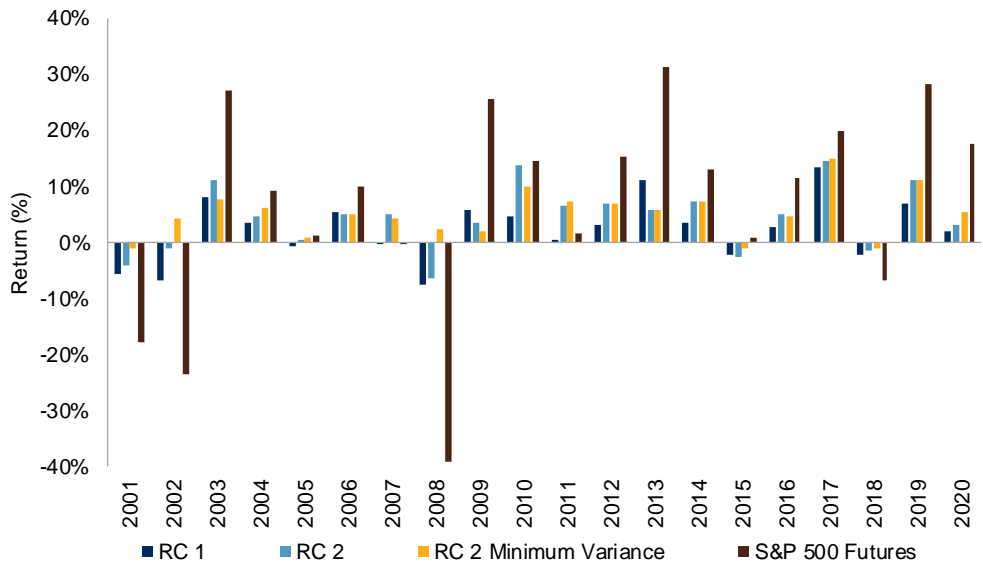
RC 1 and RC 2 are hypothetical portfolios and RC 2 Minimum Variance represents the S&P 500 Futures Daily Risk Control 5% Index.

Source: S&P Dow Jones Indices LLC. Data from Dec. 29, 2000, to Jan. 29, 2021. Index performance based on daily excess returns in USD. Past performance is no guarantee of future results. Table is provided for illustrative purposes and reflects hypothetical historical performance. Please see the Performance Disclosure at the end of this document for more information regarding the inherent limitations associated with back-tested performance.

The S&P 500 Futures Daily Risk Control 5% Index outperformed in 65% of the years between 2000 and 2020, when comparing year-over-year returns against the other risk control versions. Note that this is the only strategy that generated positive returns in 2002 and 2008, two highly volatile years (see Exhibit 10).

The S&P 500 Futures Daily Risk Control 5% Index outperformed in 65% of the years between 2000 and 2020, when comparing year-over-year...

Exhibit 10. Calendar Year Returns



...and was the only strategy to produce positive returns in 2002 and 2008, two highly volatile years.

RC 1 and RC 2 are hypothetical portfolios and RC 2 Minimum Variance represents the S&P 500 Futures Daily Risk Control 5% Index. Source: S&P Dow Jones Indices LLC. Data from Dec. 29, 2000, to Jan. 29, 2021. Index performance based on excess returns in USD. Chart is provided for illustrative purposes and reflects hypothetical historical performance. Please see the Performance Disclosure at the end of this document for more information regarding the inherent limitations associated with back-tested performance.

CONCLUSION

The RC 2 Minimum Variance strategy, i.e., the S&P 500 Futures Daily Risk Control 5% Index, is a continuation of our effort to expand our risk control techniques. The index is designed to preserve volatility targeting and provide the other benefits of Risk Control 2, while also reducing turnover during periods of heightened volatility.

In addition, by having a unique allocation to equity, bonds, and cash, the index has been able to further reduce drawdowns and historically outperform its peers especially during market sell-offs like the Tech Bubble, the Global Financial Crisis, and more recently the COVID-19 pandemic.

Overall, the S&P 500 Futures Daily Risk Control 5% Index seeks to offer an alternative to investors that seek downside protection and upside market participation, while effectively controlling daily trading volume.

S&P DJI RESEARCH CONTRIBUTORS		
Sunjiv Mainie, CFA, CQF	Global Head	sunjiv.mainie@spglobal.com
Jake Vukelic	Business Manager	jake.vukelic@spglobal.com
GLOBAL RESEARCH & DESIGN		
AMERICAS		
Gaurav Sinha	Americas Head	gaurav.sinha@spglobal.com
Laura Assis	Analyst	laura.assis@spglobal.com
Cristopher Anguiano, FRM	Senior Analyst	cristopher.anguiano@spglobal.com
Nazerke Bakytzhan, PhD	Senior Analyst	nazerke.bakytzhan@spglobal.com
Smita Chirputkar	Director	smita.chirputkar@spglobal.com
Rachel Du	Senior Analyst	rachel.du@spglobal.com
Bill Hao	Director	wenli.hao@spglobal.com
Qing Li	Director	qing.li@spglobal.com
Berlinda Liu, CFA	Director	berlinda.liu@spglobal.com
Lalit Ponnala, PhD	Director	lalit.ponnala@spglobal.com
Maria Sanchez, CIPM	Associate Director	maria.sanchez@spglobal.com
Hong Xie, CFA	Senior Director	hong.xie@spglobal.com
APAC		
Priscilla Luk	APAC Head	priscilla.luk@spglobal.com
Arpit Gupta	Senior Analyst	arpit.gupta1@spglobal.com
Akash Jain	Associate Director	akash.jain@spglobal.com
Anurag Kumar	Senior Analyst	anurag.kumar@spglobal.com
Xiaoya Qu	Senior Analyst	xiaoya.qu@spglobal.com
Yan Sun	Senior Analyst	yan.sun@spglobal.com
Tim Wang	Senior Analyst	tim.wang@spglobal.com
Liyu Zeng, CFA	Director	liyu.zeng@spglobal.com
EMEA		
Andrew Innes	EMEA Head	andrew.innes@spglobal.com
Alberto Allegrucci, PhD	Senior Analyst	alberto.allegrucci@spglobal.com
Panos Brezas, PhD	Senior Analyst	panos.brezas@spglobal.com
Leonardo Cabrer, PhD	Associate Director	leonardo.cabrer@spglobal.com
Andrew Cairns, CFA	Associate Director	andrew.cairns@spglobal.com
Niall Gilbride, CFA	Senior Analyst	niall.gilbride@spglobal.com
Rui Li, ACA	Senior Analyst	rui.li@spglobal.com
Jingwen Shi, PhD	Senior Analyst	jingwen.shi@spglobal.com
INDEX INVESTMENT STRATEGY		
Craig J. Lazzara, CFA	Global Head	craig.lazzara@spglobal.com
Fei Mei Chan	Director	feimei.chan@spglobal.com
Tim Edwards, PhD	Managing Director	tim.edwards@spglobal.com
Anu R. Ganti, CFA	Senior Director	anu.ganti@spglobal.com
Sherifa Issifu	Associate	sherifa.issifu@spglobal.com

PERFORMANCE DISCLOSURE/BACK-TESTED DATA

The S&P 500 Futures Daily Risk Control 5% Index was launched December 18, 2020. All information presented prior to an index's Launch Date is hypothetical (back-tested), not actual performance. The back-test calculations are based on the same methodology that was in effect on the index Launch Date. However, when creating back-tested history for periods of market anomalies or other periods that do not reflect the general current market environment, index methodology rules may be relaxed to capture a large enough universe of securities to simulate the target market the index is designed to measure or strategy the index is designed to capture. For example, market capitalization and liquidity thresholds may be reduced. Complete index methodology details are available at www.spglobal.com/spdji. Past performance of the Index is not an indication of future results. Back-tested performance reflects application of an index methodology and selection of index constituents with the benefit of hindsight and knowledge of factors that may have positively affected its performance, cannot account for all financial risk that may affect results and may be considered to reflect survivor/look ahead bias. Actual returns may differ significantly from, and be lower than, back-tested returns. Past performance is not an indication or guarantee of future results. Please refer to the methodology for the Index for more details about the index, including the manner in which it is rebalanced, the timing of such rebalancing, criteria for additions and deletions, as well as all index calculations. Back-tested performance is for use with institutions only; not for use with retail investors.

S&P Dow Jones Indices defines various dates to assist our clients in providing transparency. The First Value Date is the first day for which there is a calculated value (either live or back-tested) for a given index. The Base Date is the date at which the index is set to a fixed value for calculation purposes. The Launch Date designates the date when the values of an index are first considered live: index values provided for any date or time period prior to the index's Launch Date are considered back-tested. S&P Dow Jones Indices defines the Launch Date as the date by which the values of an index are known to have been released to the public, for example via the company's public website or its data feed to external parties. For Dow Jones-branded indices introduced prior to May 31, 2013, the Launch Date (which prior to May 31, 2013, was termed "Date of introduction") is set at a date upon which no further changes were permitted to be made to the index methodology, but that may have been prior to the Index's public release date.

Typically, when S&P DJI creates back-tested index data, S&P DJI uses actual historical constituent-level data (e.g., historical price, market capitalization, and corporate action data) in its calculations. As ESG investing is still in early stages of development, certain datapoints used to calculate S&P DJI's ESG indices may not be available for the entire desired period of back-tested history. The same data availability issue could be true for other indices as well. In cases when actual data is not available for all relevant historical periods, S&P DJI may employ a process of using "Backward Data Assumption" (or pulling back) of ESG data for the calculation of back-tested historical performance. "Backward Data Assumption" is a process that applies the earliest actual live data point available for an index constituent company to all prior historical instances in the index performance. For example, Backward Data Assumption inherently assumes that companies currently not involved in a specific business activity (also known as "product involvement") were never involved historically and similarly also assumes that companies currently involved in a specific business activity were involved historically too. The Backward Data Assumption allows the hypothetical back-test to be extended over more historical years than would be feasible using only actual data. For more information on "Backward Data Assumption" please refer to the [FAQ](#). The methodology and factsheets of any index that employs backward assumption in the back-tested history will explicitly state so. The methodology will include an Appendix with a table setting forth the specific data points and relevant time period for which backward projected data was used.

Index returns shown do not represent the results of actual trading of investable assets/securities. S&P Dow Jones Indices maintains the index and calculates the index levels and performance shown or discussed but does not manage actual assets. Index returns do not reflect payment of any sales charges or fees an investor may pay to purchase the securities underlying the Index or investment funds that are intended to track the performance of the Index. The imposition of these fees and charges would cause actual and back-tested performance of the securities/fund to be lower than the Index performance shown. As a simple example, if an index returned 10% on a US \$100,000 investment for a 12-month period (or US \$10,000) and an actual asset-based fee of 1.5% was imposed at the end of the period on the investment plus accrued interest (or US \$1,650), the net return would be 8.35% (or US \$8,350) for the year. Over a three-year period, an annual 1.5% fee taken at year end with an assumed 10% return per year would result in a cumulative gross return of 33.10%, a total fee of US \$5,375, and a cumulative net return of 27.2% (or US \$27,200).

GENERAL DISCLAIMER

Copyright © 2021 S&P Dow Jones Indices LLC. All rights reserved. S&P, S&P 500, S&P 500 LOW VOLATILITY INDEX, S&P 100, S&P COMPOSITE 1500, S&P MIDCAP 400, S&P SMALLCAP 600, SELECT SECTOR, S&P GIVI, GLOBAL TITANS, DIVIDEND ARISTOCRATS, S&P TARGET DATE INDICES, S&P PRISM, S&P STRIDE, GICS, SPIVA, SPDR and INDEXOLOGY are registered trademarks of Standard & Poor's Financial Services LLC, a division of S&P Global ("S&P"). DOW JONES, DJ, DJIA, The Dow and DOW JONES INDUSTRIAL AVERAGE are registered trademarks of Dow Jones Trademark Holdings LLC ("Dow Jones"). These trademarks together with others have been licensed to S&P Dow Jones Indices LLC. Redistribution or reproduction in whole or in part are prohibited without written permission of S&P Dow Jones Indices LLC. This document does not constitute an offer of services in jurisdictions where S&P Dow Jones Indices LLC, S&P, Dow Jones or their respective affiliates (collectively "S&P Dow Jones Indices") do not have the necessary licenses. Except for certain custom index calculation services, all information provided by S&P Dow Jones Indices is impersonal and not tailored to the needs of any person, entity or group of persons. S&P Dow Jones Indices receives compensation in connection with licensing its indices to third parties and providing custom calculation services. Past performance of an index is not an indication or guarantee of future results.

It is not possible to invest directly in an index. Exposure to an asset class represented by an index may be available through investable instruments based on that index. S&P Dow Jones Indices does not sponsor, endorse, sell, promote or manage any investment fund or other investment vehicle that is offered by third parties and that seeks to provide an investment return based on the performance of any index. S&P Dow Jones Indices makes no assurance that investment products based on the index will accurately track index performance or provide positive investment returns. S&P Dow Jones Indices LLC is not an investment advisor, and S&P Dow Jones Indices makes no representation regarding the advisability of investing in any such investment fund or other investment vehicle. A decision to invest in any such investment fund or other investment vehicle should not be made in reliance on any of the statements set forth in this document. Prospective investors are advised to make an investment in any such fund or other vehicle only after carefully considering the risks associated with investing in such funds, as detailed in an offering memorandum or similar document that is prepared by or on behalf of the issuer of the investment fund or other investment product or vehicle. S&P Dow Jones Indices LLC is not a tax advisor. A tax advisor should be consulted to evaluate the impact of any tax-exempt securities on portfolios and the tax consequences of making any particular investment decision. Inclusion of a security within an index is not a recommendation by S&P Dow Jones Indices to buy, sell, or hold such security, nor is it considered to be investment advice.

These materials have been prepared solely for informational purposes based upon information generally available to the public and from sources believed to be reliable. No content contained in these materials (including index data, ratings, credit-related analyses and data, research, valuations, model, software or other application or output therefrom) or any part thereof ("Content") may be modified, reverse-engineered, reproduced or distributed in any form or by any means, or stored in a database or retrieval system, without the prior written permission of S&P Dow Jones Indices. The Content shall not be used for any unlawful or unauthorized purposes. S&P Dow Jones Indices and its third-party data providers and licensors (collectively "S&P Dow Jones Indices Parties") do not guarantee the accuracy, completeness, timeliness or availability of the Content. S&P Dow Jones Indices Parties are not responsible for any errors or omissions, regardless of the cause, for the results obtained from the use of the Content. THE CONTENT IS PROVIDED ON AN "AS IS" BASIS. S&P DOW JONES INDICES PARTIES DISCLAIM ANY AND ALL EXPRESS OR IMPLIED WARRANTIES, INCLUDING, BUT NOT LIMITED TO, ANY WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE OR USE, FREEDOM FROM BUGS, SOFTWARE ERRORS OR DEFECTS, THAT THE CONTENT'S FUNCTIONING WILL BE UNINTERRUPTED OR THAT THE CONTENT WILL OPERATE WITH ANY SOFTWARE OR HARDWARE CONFIGURATION. In no event shall S&P Dow Jones Indices Parties be liable to any party for any direct, indirect, incidental, exemplary, compensatory, punitive, special or consequential damages, costs, expenses, legal fees, or losses (including, without limitation, lost income or lost profits and opportunity costs) in connection with any use of the Content even if advised of the possibility of such damages.

S&P Global keeps certain activities of its various divisions and business units separate from each other in order to preserve the independence and objectivity of their respective activities. As a result, certain divisions and business units of S&P Global may have information that is not available to other business units. S&P Global has established policies and procedures to maintain the confidentiality of certain non-public information received in connection with each analytical process.

In addition, S&P Dow Jones Indices provides a wide range of services to, or relating to, many organizations, including issuers of securities, investment advisers, broker-dealers, investment banks, other financial institutions and financial intermediaries, and accordingly may receive fees or other economic benefits from those organizations, including organizations whose securities or services they may recommend, rate, include in model portfolios, evaluate or otherwise address.