

Don't Throw out the Return with the Risk: Average Variance Portfolio Management

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How Risky is your Aversion?

Risk Anomaly

Data

Variance De- composition

Results

In Sample

Out of Sample

Asset Allocation

Explanation

Conclusions

- Higher Return is better than lower return, lower risk is better than higher risk

How Risky is your Aversion?

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- Leverage - access to higher returns at higher risk

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- Time leverage on a component which predicts higher risk you can decrease exposure ahead of risky times

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- Time leverage on a component which predicts higher risk you can decrease exposure ahead of risky times
- Are you giving up potential returns?

Equity Premium

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Equity Premium

- Markowitz (1952) - formal portfolio variance, return optimization

- Volatility Managed Market Investment

Equity Premium

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 - $W_t R_{st}$ where R_{st} is the monthly return to the CRSP market portfolio in month t .

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 - $W_t R_{st}$ where R_{st} is the monthly return to the CRSP market portfolio in month t .
 - $\sigma^2(r_{s,t-1})$ is the variance, where $r_{s,t-1}$ is the series of daily returns of the CRSP market portfolio for month $t-1$

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 - $W_t R_{st}$ where R_{st} is the monthly return to the CRSP market portfolio in month t.
 - $\sigma^2(r_{s,t-1})$ is the variance, where $r_{s,t-1}$ is the series of daily returns of the CRSP market portfolio for month t-1
 - $W_t = \frac{1}{\sigma^2(r_{s,t-1})}$ is the investment weight on the CRSP market portfolio for month t

Moreira and Muir 2017

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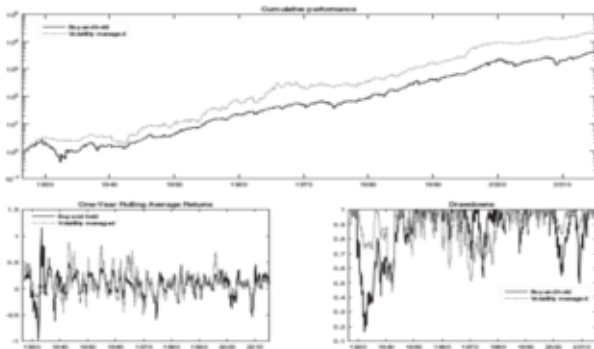
The Journal of Finance[®]

Figure 3. Cumulative returns to the volatility-managed market return. The top panel plots the cumulative returns to a buy-and-hold strategy versus a volatility-managed strategy for the market portfolio from 1926 to 2015. The y-axis is on a log scale and both strategies have the same unconditional monthly standard deviation. The lower left panel plots rolling one-year returns from each strategy and the lower right panel shows the drawdown of each strategy.

Variance Decomposition

Market Variance

Variance Decomposition

Market Variance

- Campbell, Lettau, and Xu (2001) - variance of individual assets vs market variance and CAPM

Variance Decomposition

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- Pollet and Wilson (2010) - decompose quarterly variance of market portfolio - Avg cor and Avg var

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Avg Var and Avg Cor

$$R_{s,t} = \sum_1^N w_{n,t} R_{n,t}$$

$$\sigma^2(r_{s,t}) = \sum_{n=1}^N \sum_{m=1}^N w_{n,t} w_{m,t} \sigma_{n,t}^2 \sigma_{m,t}^2 \rho_{n,m,t}$$

$$\sigma_{s,t}^2 = \sum_{n=1}^N w_{n,t} \sigma_{n,t}^2 \times \sum_{n=1}^N \sum_{m \neq n}^N w_{n,t} w_{m,t} \rho_{n,m,t}$$

$$AV_t = \sum_{n=1}^N w_{n,t} \sigma_{n,t}^2 \quad \text{and} \quad AC_t = \sum_{n=1}^N \sum_{m \neq n}^N w_{n,t} w_{m,t} \rho_{n,m,t}$$

Pollet and Wilson 2010 - Risk

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Table: 1963Q2:2007Q1

	SV_{t+1}				
AC_t	0.014*** (0.005)		0.005 (0.005)		
AV_t		0.144*** (0.023)	0.136*** (0.024)		0.188*** (0.042)
SV_t				0.310*** (0.072)	-0.156 (0.124)
Constant	0.002 (0.001)	0.002** (0.001)	0.001 (0.001)	0.003*** (0.001)	0.001** (0.001)
Observations	176	176	176	176	176
R^2	0.042	0.184	0.096	0.096	0.191
Adjusted R^2	0.037	0.179	0.091	0.091	0.182

Note:

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

Pollet and Wilson 2010 - Returns

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Table: 1963Q2:2007Q1

	RET _{t+1}				
AC _t	0.215*** (0.068)		0.248*** (0.072)		
AV _t		-0.116 (0.347)	-0.512 (0.356)		-1.746*** (0.615)
SV _t				1.466 (1.026)	5.795*** (1.828)
Constant	-0.038** (0.017)	0.014 (0.010)	-0.034** (0.017)	0.005 (0.008)	0.022** (0.010)
Observations	176	176	176	176	176
R ²	0.054	0.001	0.065	0.012	0.056
Adjusted R ²	0.049	-0.005	0.054	0.006	0.045

Note:

*p<0.1; **p<0.05; ***p<0.01

Average Variance

- Timing leverage by variance generates higher returns

Average Variance

- Timing leverage by variance generates higher returns
- Market variance contains average correlation

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Average Variance

- Timing leverage by variance generates higher returns
- Market variance contains average correlation
- Average variance is at least unrelated to future returns

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- $W_t = \frac{1}{AV_{t-1}}$ is the investment weight on the CRSP market portfolio

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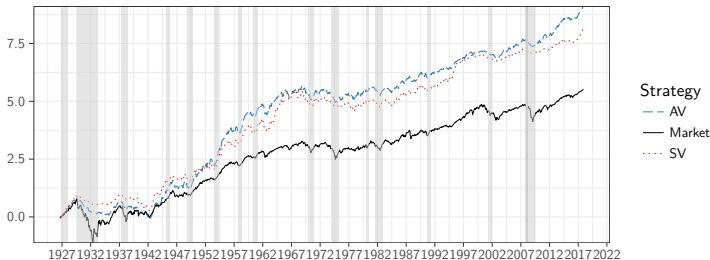
Explanation

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-

Cummulative Excess Log Returns - Monthly



CRSP daily returns

- NYSE daily return (1926-2017)
- NYSE-AMEX daily returns (1962-2017)
- NASDAQ daily returns (1974-2017)
- Monthly Variance Stats and MCAP of gaming industry

Asaif Manela's Website

- $ICRF = \frac{MarEq}{MarEq + BookDbt}$ He, Kelly, Manela (2017)
- $LF_{AEM} = \frac{FinAsst}{FinAsst - BankDbt}$ Adrian, Etula and Muir (2014)
- BC = year on year increase in bank credit Gandhi (2016)

NYSE

- ΔMD = month to month change in Margin Debt

Summary Stats

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Monthly 1962M6:2016M12

Statistic	N	Mean	St. Dev.	Min	Max	Autocorrelation
RET	655	0.410	4.460	-26.134	14.814	0.081
AC	655	0.261	0.129	0.019	0.762	0.620
AV	655	0.770	0.849	0.198	10.416	0.667
SV	655	0.200	0.406	0.006	5.664	0.551

Monthly 1926M7:2016M12

Statistic	N	Mean	St. Dev.	Min	Max	Autocorrelation
RET	1,085	0.495	5.371	-34.523	33.188	0.106
AC	1,085	0.276	0.134	0.019	0.762	0.610
AV	1,085	0.881	1.281	0.154	19.540	0.718
SV	1,085	0.248	0.502	0.006	5.808	0.612

Variance Prediction

Risk Anomaly

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Sample 1962M6:2016M12

	SV_{t+1}				
AC_t	0.010*** (0.001)			0.005*** (0.001)	
AV_t		0.261*** (0.016)		0.234*** (0.017)	0.123*** (0.035)
SV_t			0.551*** (0.033)		0.320*** (0.074)
Constant	-0.001** (0.0003)	-0.00001 (0.0002)	0.001*** (0.0001)	-0.001*** (0.0003)	0.0004** (0.0002)
Observations	654	654	654	654	654
R^2	0.110	0.297	0.304	0.320	0.317
Adjusted R^2	0.109	0.296	0.303	0.318	0.315

Note:

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

AV Prediction

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Sample 1962M6:2016M12

	AV_{t+1}				
AC_t	0.014*** (0.003)			-0.001 (0.002)	
AV_t		0.667*** (0.029)		0.674*** (0.031)	1.030*** (0.065)
SV_t			1.092*** (0.070)		-0.844*** (0.135)
Constant	0.004*** (0.001)	0.003*** (0.0003)	0.006*** (0.0003)	0.003*** (0.001)	0.001*** (0.0004)
Observations	654	654	654	654	654
R^2	0.048	0.445	0.273	0.446	0.477
Adjusted R^2	0.046	0.445	0.272	0.444	0.475

Note:

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

Return Prediction

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Sample 1962M6:2016M12

		RET _{t+1}			
AC _t	0.017 (0.013)			0.037*** (0.014)	
AV _t		-0.678*** (0.203)		-0.877*** (0.216)	-0.905* (0.463)
SV _t			-1.174*** (0.426)		0.526 (0.969)
Constant	-0.0001 (0.004)	0.009*** (0.002)	0.007*** (0.002)	0.001 (0.004)	0.010*** (0.003)
Observations	655	655	655	655	655
R ²	0.002	0.017	0.012	0.027	0.017
Adjusted R ²	0.001	0.015	0.010	0.024	0.014

Note:

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Out-of-Sample Tests

- Divide the sample 1962:06 - 2016:12 into 15% training
85% prediction

Out-of-Sample Tests

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- Divide the sample 1962:06 - 2016:12 into 15% training 85% prediction
 - Initial training period $t = q$ months. First 8 years.

Out-of-Sample Tests

- Divide the sample 1962:06 - 2016:12 into 15% training 85% prediction
 - Initial training period $t = q$ months. First 8 years.
 - Remaining period $t = q + 1, q + 2, \dots, T$ for out-of-sample forecast evaluation.

Out-of-Sample Tests

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 - Estimate $\hat{\alpha}_t$ and $\hat{\beta}_t$ by regressing $\{r_{s+1}\}_{s=1}^{t-1}$ on a constant and $\{x\}_{s=1}^{t-1}$

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 - Estimate $\hat{\alpha}_t$ and $\hat{\beta}_t$ by regressing $\{r_{s+1}\}_{s=1}^{t-1}$ on a constant and $\{x\}_{s=1}^{t-1}$
- Generate one period ahead prediction

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 - $\hat{r}_{t+1} = \hat{\alpha}_t + \hat{\beta}_t x_t$

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- Generate one period ahead prediction
 - $\hat{r}_{t+1} = \hat{\alpha}_t + \hat{\beta}_t x_t$
- Each following month the "training" window expands by one month

Out of Sample Stats

- $y_t - \hat{y}_{x,t} = e_{x,t}$: forecast error of predictor x
- $\frac{1}{T} \sum_1^T (e_{x,t})^2 = \text{MSFE}_x$: mean squared forecast error based on predictor x

R_{oos}^2 Campbell and Thompson 2007

- $R_{\text{os}}^2 = 1 - \frac{\text{MSFE}_x}{\text{MSFE}_b}$
- R_{os}^2 = proportional reduction in MSFE

MSE-F Mcracken 2004

- $\text{MSE-F} = T \times \frac{\frac{1}{T} \sum_1^T (e_{b,t}^2 - e_{x,t}^2)}{\text{MSFE}_x}$
- MSE-F = F-type test for significance in squared residual (like in sample regression)

Out of Sample Stats

- R_{OOS}^2 and MSE-F test improvement in forecast accuracy relative to a benchmark
- Encompassing tests impose the greater requirement that the benchmark have no valuable forecasting information

ENC-NEW Mcracken and Clark 2009

- $$\text{ENC-NEW} = T \times \frac{\frac{1}{T} \sum_1^T (e_{b,t}^2 - e_{b,t} e_{x,t})}{MSFE_x}$$
- ENC-NEW = F-type statistic on the improvement of including the benchmark

ENC-HLN Harvey, Lebourne and Newbold 1998

- Optimal forecast = $\hat{y}_t^* = (1 - \lambda)\hat{y}_{b,t} + \lambda\hat{y}_{x,t}$
- λ = measure of the optimal combination of forecasts from x and the benchmark

Out of Sample Results

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Table: 1970M7:2016M12

Benchmark: Historical Average

	Sample	R^2_{oos}	MSE-F	ENC-NEW	ENC-HLN
SV_{t+1}	Monthly	25.414*	189.790***	160.994**	1***
AV_{t+1}	Monthly	38.11**	342.979***	355.228**	0.967***
RET_{t+1}	Monthly	-0.059	-0.328	3.493**	0.478

Benchmark: SV_t

	Sample	R^2_{oos}	MSE-F	ENC-NEW	ENC-HLN
SV_{t+1}	Monthly	4.041	23.454***	25.409**	0.929*
AV_{t+1}	Monthly	26.853	204.485***	135.494**	1***
RET_{t+1}	Monthly	2.116	12.043***	8.2**	1

Out of Sample Results

Table: 1932M2:1962M6

Benchmark: Historical Average

	Sample	R^2_{oos}	MSE-F	ENC-NEW	ENC-HLN
SV_{t+1}	Monthly	49.972***	367.592***	397.183**	0.931***
AV_{t+1}	Monthly	50.747**	379.160***	409.061**	0.932***
RET_{t+1}	Monthly	-8.708	-29.479	-9.96	0

Benchmark: SV_t

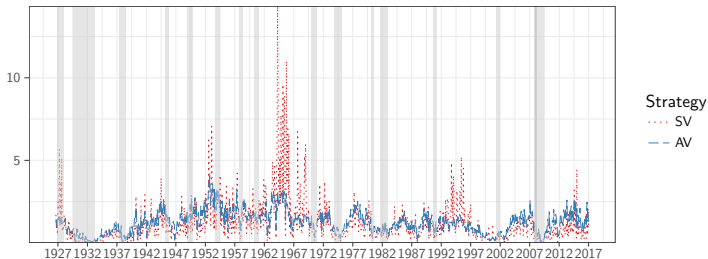
	Sample	R^2_{oos}	MSE-F	ENC-NEW	ENC-HLN
SV_{t+1}	Monthly	-1.289	-4.682	76.562**	0.485*
AV_{t+1}	Monthly	11.328	47.013***	121.513**	0.62**
RET_{t+1}	Monthly	-6.098	-21.152	-6.192	0

Investment Weight

$$w_{AV,t} = \frac{c_{AV}}{AV_{t-1}} \text{ and } w_{SV,t} = \frac{c_{SV}}{SV_{t-1}}$$

c is a constant used to equalize the standard deviation of strategies to the buy and hold

Strategy Investment Weight



Statistic	N	Mean	St. Dev.	Min	Max
$w_{SV,t}$	1,085	1.290	1.412	0.017	16.193
$w_{AV,t}$	1,085	1.301	0.710	0.033	4.253

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- $RET = \text{annualized average log excess return}$

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- $RET = \text{annualized average log excess return}$
- $Sharpe = \frac{\mathbb{E}[R_x]}{\sigma(R_x)}$, dollar of returns for dollar of variance

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- $Sharpe = \frac{\mathbb{E}[R_x]}{\sigma(R_x)}$, dollar of returns for dollar of variance
- $Sortino = \frac{\mathbb{E}[R_x - 0]}{\sqrt{\int_{-\infty}^0 (0 - R_x)^2 f(R_x) dR}}$, return for downside

Performance Measures

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- Kappa(n) = $\frac{\mathbb{E}[R_x - 0]}{\sqrt[n]{LPM_n}}$, where LPM is lower partial moment
Kappa[2] = Sortino

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- $Kappa(n) = \frac{\mathbb{E}[R_x - 0]}{\sqrt[n]{LPM_n}}$, where LPM is lower partial moment
 $Kappa[2] = Sortino$
- $UpsidePotential = \frac{\mathbb{E}[(R_x - 0)_+]}{\sqrt{\mathbb{E}[(R_x - 0)_-^2]}}$, dollar of average gain for downside risk

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 $Kappa[2] = Sortino$
- $UpsidePotential = \frac{\mathbb{E}[(R_x - 0)_+]}{\sqrt{\mathbb{E}[(R_x - 0)_-^2]}}$, dollar of average gain for downside risk
- $Rachev = \frac{ETL_{\alpha}(r_f - x' r)}{ETL_{\beta}(x' r - r_f)}$ where $ETL_{\alpha} = \frac{1}{\alpha} \int_0^{\alpha} VaR_q(X) dq$, dollar of possible extreme gain for dollar of possible extreme loss

Performance

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1926M7:2016M12

Strategy	RET	Sharpe	Sortino	Kappa	UpsidePotential	Rachev
BH	5.932	0.319	0.447	0.082	0.584	0.841
SV	8.598	0.462	0.722	0.132	0.650	1.151
AV	9.677	0.520	0.778	0.150	0.706	0.972

1962M6:2016M12

Strategy	RET	Sharpe	Sortino	Kappa	UpsidePotential	Rachev
BH	5.112	0.332	0.463	0.089	0.635	0.826
SV	7.311	0.406	0.647	0.122	0.663	1.212
AV	7.857	0.470	0.702	0.139	0.719	0.987

Drawdowns

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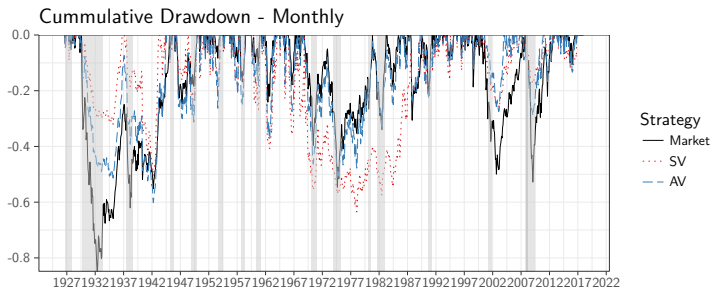
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Strategy	N	Max DD	Avg DD	Max Length	Avg Length	Max Recovery	Avg Recovery
BH	82	-84.803	-8.069	188	11.549	154	7.207
SV	65	-63.508	-11.162	246	14.954	135	7.446
AV	87	-60.208	-9.014	205	10.851	135	5.034

Risk over Reward

Risk Anomaly

Data

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- The higher excess returns of low-risk strategies (assets) comes from a preference for the lottery like extreme returns possible from higher risk investments - Barberis and Huang (2008); Brunnermeier, Gollier, and Parker (2007); Asness, Frazzini, Gorsmen, Pedersen (2016)

Risk over Reward

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- The higher excess returns of low-risk strategies (assets) comes from a preference for the lottery like extreme returns possible from higher risk investments - Barberis and Huang (2008); Brunnermeier, Gollier, and Parker (2007); Asness, Frazzini, Gorsmen, Pedersen (2016)
- Leverage constraints prevent investors from taking the low-risk position - Black (1972)

Lottery

- For lottery preferences to explain the higher returns of either SV or AV, the Buy and Hold strategy must be more lottery-like than either

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-

Strategy	MAX1			SMAX1		
	Mean	Median	Sd	Mean	Median	Sd
BH	1.776	1.422	1.398	2.186	1.971	1.046
SV	1.569	1.258	1.243	3.229	2.167	4.661
AV	1.796	1.650	0.960	2.884	1.691	4.992

Strategy	MAX5			SMAX5		
	Mean	Median	Sd	Mean	Median	Sd
BH	1.134	0.922	0.774	1.410	1.341	0.540
SV	1.023	0.842	0.787	2.084	1.377	2.765
AV	1.164	1.088	0.534	1.827	1.121	2.833

Lottery Pick 2

$$R_t^{AV} = \alpha_t + \beta_t^1 R_t^M + \beta_t^2 R_t^M * x_1 + \beta_t \chi_t \quad (1)$$

	AV			
BH	0.880*** (0.027)	0.939*** (0.027)	0.880*** (0.030)	0.940*** (0.029)
GMCAP	0.000 (0.000)	0.000 (0.000)		
BH*GMCAP	-0.000 (0.000)	-0.000 (0.000)		
GMCAP ₅₀₀			0.524 (0.998)	0.660 (0.948)
BH*GMCAP ₅₀₀			-18.636 (24.213)	-15.823 (22.993)
Controls	FF-3	FF-5	FF-3	FF-5
Observations	525	525	525	525
R ²	0.749	0.775	0.749	0.775
Adjusted R ²	0.747	0.772	0.747	0.772

Performance Issues

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Weights [0,1.5]

Strategy	RET	Sharpe	Sortino	Kappa	UpsidePotential	Rachev
BH	5.932	0.319	0.447	0.082	0.584	0.841
SV	6.171	0.467	0.691	0.128	0.667	0.982
AV	7.885	0.486	0.706	0.133	0.683	0.896

Weights [0,1]

Strategy	RET	Sharpe	Sortino	Kappa	UpsidePotential	Rachev
BH	5.932	0.319	0.447	0.082	0.584	0.841
SV	4.649	0.433	0.619	0.113	0.646	0.897
AV	5.814	0.447	0.632	0.117	0.657	0.845

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AV								
BH	0.724*** (0.027)	0.805*** (0.029)	0.788*** (0.042)	0.843*** (0.041)	0.804*** (0.033)	0.889*** (0.035)	0.858*** (0.025)	0.900*** (0.026)
LF _{AEM}	0.178*** (0.038)	0.134*** (0.037)						
BH*LF _{AEM}	1.231*** (0.352)	1.508*** (0.341)						
ICRF			0.0004 (0.026)	0.006 (0.025)				
BH*ICRF			0.301 (0.196)	0.308 (0.188)				
BC					-0.0002 (0.0002)	-0.0001 (0.0002)		
BH*BC					0.001 (0.004)	-0.003 (0.004)		
Δ MD ₁₉₈₄							0.00000 (0.00000)	0.00000 (0.00000)
BH*Δ MD ₁₉₈₄							0.00002*** (0.00000)	0.00002*** (0.00000)
Controls	FF-3	FF-5	FF-3	FF-5	FF-3	FF-5	FF-3	FF-5
Observations	396	396	396	396	432	432	431	431
R ²	0.764	0.785	0.748	0.771	0.739	0.761	0.772	0.791
Adjusted R ²	0.761	0.781	0.745	0.767	0.736	0.757	0.770	0.788

Note*


 *p<0.1; **p<0.05; ***p<0.01

Leverage

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	AV					
BH	0.596*** (0.065)	0.675*** (0.065)	0.445*** (0.097)	0.619*** (0.102)	0.561*** (0.075)	0.661*** (0.075)
Broker _{call}	-0.0004 (0.0005)	-0.001 (0.0005)				
BH*Broker _{call}	0.033*** (0.012)	0.039*** (0.012)				
Bank _{call}			0.00002 (0.001)	0.00005 (0.001)		
BH*Bank _{call}			0.061*** (0.013)	0.044*** (0.013)		
Bank _{prime}					-0.001 (0.0004)	-0.001 (0.0004)
BH*Bank _{prime}					0.037*** (0.011)	0.033*** (0.010)
Observations	336	336	265	265	395	395
R ²	0.678	0.712	0.802	0.818	0.729	0.753
Adjusted R ²	0.673	0.706	0.798	0.813	0.726	0.749

Note*

*p<0.1; **p<0.05; ***p<0.01



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- Market variation contains average correlation which is compensated by higher returns

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- Market variation contains average correlation which is compensated by higher returns
- SV management throws out return with risk, AV does not

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- Market variation contains average correlation which is compensated by higher returns
- SV management throws out return with risk, AV does not
- AV out performs in all most all measures

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- Market variation contains average correlation which is compensated by higher returns
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- Neither SV nor AV can be explained as behavior, lottery preference stories

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- Market variation contains average correlation which is compensated by higher returns
- SV management throws out return with risk, AV does not
- AV out performs in all most all measures
- Neither SV nor AV can be explained as behavior, lottery preference stories
- Leverage constraints are a better explanation of the returns to SV and AV above the market

- Portfolio performance significance
- Different c adjustments (don't require knowing the BH variance)
- Subsample robust stats - Inoue and Rossi (2012)
- Expand the left hand side - international / portfolio of equity indexes
- AV utility gains

Monthly Measures of Daily Return Statistics

