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

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- Volatility Managed Market Investment

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  - $\sigma^2(r_{s,t-1})$ 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

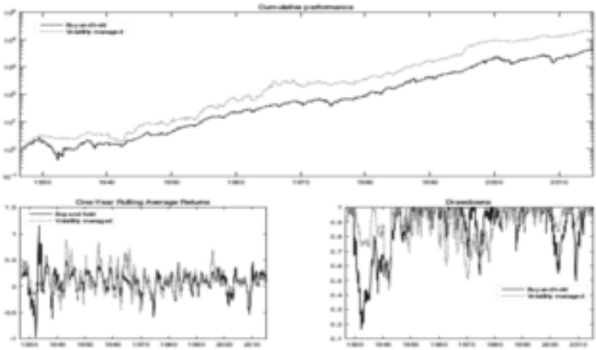

Figure 3. Cumulative returns to the volatility-managed market return. The top panel plots the cumulative returns to a buy-and-hold strategy versus a volatility-managed strategy for the market portfolio from 1926 to 2015. The y-axis is on a log scale and both strategies have the same unconditional monthly 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

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Avg Var and Avg Cor

$$R_{s,t} = \sum_{1}^{N} w_{n,t} R_{n,t}$$

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

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

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

Pollet and Wilson 2010 - Risk

Table: 1963Q2:2007Q1

	SV_{t+1}				
AC_t	0.014***		0.005		
	(0.005)		(0.005)		
AV_t		0.144***	0.136***		0.188***
		(0.023)	(0.024)		(0.042)
SV_t				0.310***	−0.156
				(0.072)	(0.124)
Constant	0.002	0.002**	0.001	0.003***	0.001**
	(0.001)	(0.001)	(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

Table: 1963Q2:2007Q1

	RET_{t+1}				
AC_t	0.215***		0.248***		
	(0.068)		(0.072)		
AV_t		−0.116	−0.512		−1.746***
		(0.347)	(0.356)		(0.615)
SV_t				1.466	5.795***
				(1.026)	(1.828)
Constant	−0.038**	0.014	−0.034**	0.005	0.022**
	(0.017)	(0.010)	(0.017)	(0.008)	(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

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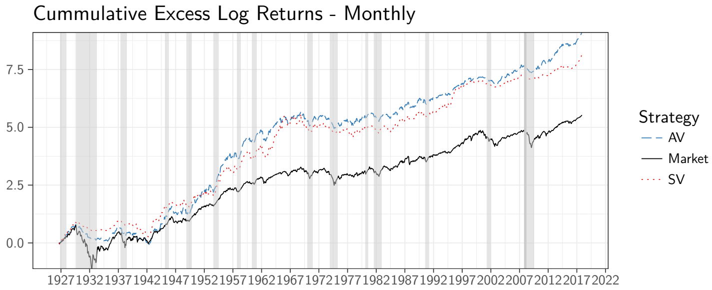
- 

Data

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

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

NYSE

- Δ MD = month to month change in Margin Debt

Summary Stats

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

Sample 1962M6:2016M12

	SV_{t+1}				
AC_t	0.010***			0.005***	
	(0.001)			(0.001)	
AV_t		0.261***		0.234***	0.123***
		(0.016)		(0.017)	(0.035)
SV_t			0.551***		0.320***
			(0.033)		(0.074)
Constant	−0.001**	−0.00001	0.001***	−0.001***	0.0004**
	(0.0003)	(0.0002)	(0.0001)	(0.0003)	(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

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

Sample 1962M6:2016M12

	RET_{t+1}				
AC_t	0.017			0.037^{***}	
	(0.013)			(0.014)	
AV_t		-0.678^{***}		-0.877^{***}	-0.905^{*}
		(0.203)		(0.216)	(0.463)
SV_t			-1.174^{***}		0.526
			(0.426)		(0.969)
Constant	-0.0001	0.009^{***}	0.007^{***}	0.001	0.010^{***}
	(0.004)	(0.002)	(0.002)	(0.004)	(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
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- 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 preditor x
- $\frac{1}{T}\sum_1^T(e_{x,t})^2 = \text{MSFE}_x$: mean squared forecast error based on predictor x

R^2_{oos} Campbell and Thompson 2007

- $R^2_{os} = 1 - \frac{MSFE_x}{MSFE_b}$
- R^2_{os} = proportional reduction in MSFE

MSE-F Mcracken 2004

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

Out of Sample Stats

- R^2_{oos} 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

- 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 imporvement 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

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

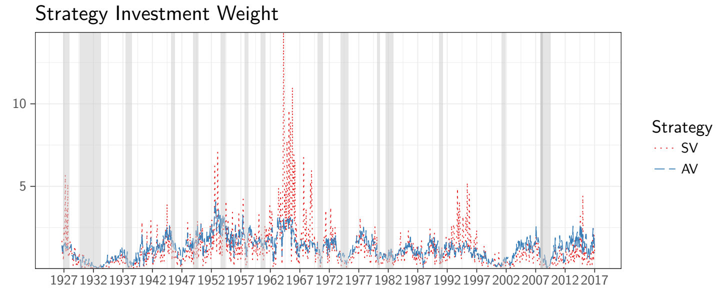
Benchmark: SV_t

	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

$w_{AV,t} = \frac{c_{AV}}{AV_{t-1}}$ 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



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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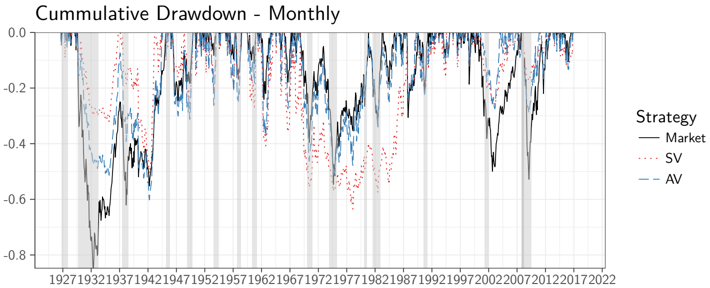
- Rachev $= \frac{ETL_\alpha(r_f - x'r)}{ETL_\beta(x'r - r_f)}$ where $ETL_\alpha = \frac{1}{\alpha}\int_0^\alpha VaR_q(X)\, dq$, dollar of possible extreme gain for dollar of possible extreme loss

Performance

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



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

- 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)

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- Leverage constraints prevent investors from taking the low-risk position - Black (1972)

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	MAX1			SMAX1		
Strategy	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
	MAX5			**SMAX5**		
Strategy	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

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

	AV			
BH	0.880***	0.939***	0.880***	0.940***
	(0.027)	(0.027)	(0.030)	(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	0.660
			(0.998)	(0.948)
$BH*GMCAP_{500}$			−18.636	−15.823
			(24.213)	(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

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

Leverage

	AV							
BH	0.724***	0.805***	0.788***	0.843***	0.804***	0.889***	0.858***	0.900***
	(0.027)	(0.029)	(0.042)	(0.041)	(0.033)	(0.035)	(0.025)	(0.026)
LF_{AEM}	0.178***	0.134***						
	(0.038)	(0.037)						
$BH*LF_{AEM}$	1.231***	1.508***						
	(0.352)	(0.341)						
ICRF			0.0004	0.006				
			(0.026)	(0.025)				
BH*ICRF			0.301	0.308				
			(0.196)	(0.188)				
BC					−0.0002	−0.0001		
					(0.0002)	(0.0002)		
BH*BC					0.001	−0.003		
					(0.004)	(0.004)		
$\Delta\ MD_{1984}$							0.00000	0.00000
							(0.00000)	(0.00000)
$BH*\Delta\ MD_{1984}$							0.00002***	0.00002***
							(0.00000)	(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

	AV					
BH	0.596***	0.675***	0.445***	0.619***	0.561***	0.661***
	(0.065)	(0.065)	(0.097)	(0.102)	(0.075)	(0.075)
$Broker_{call}$	−0.0004	−0.001				
	(0.0005)	(0.0005)				
$BH{*}Broker_{call}$	0.033***	0.039***				
	(0.012)	(0.012)				
$Bank_{call}$			0.00002	0.00005		
			(0.001)	(0.001)		
$BH{*}Bank_{call}$			0.061***	0.044***		
			(0.013)	(0.013)		
$Bank_{Prime}$					−0.001	−0.001
					(0.0004)	(0.0004)
$BH{*}Bank_{Prime}$					0.037***	0.033***
					(0.011)	(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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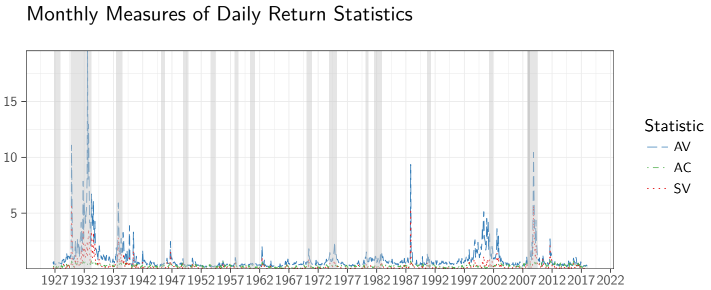
- Neither SV nor AV can be expained as behavior, lottery preference stories
- Leverage constraints are a better explaination of the returns to SV and AV above the market

TO DO

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

Time Series


Monthly Measures of Daily Return Statistics
15
10
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1927
1932
1937
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2017
2022
Statistic
AV
AC
SV