Does Volatility Timing Work When it Matters?

Presentation at:

Research Methods and Study Skills

April 20, 2018

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[joint work with **Nikolaos Tessaromatis** (EDHEC Business School and EDHEC Risk Institute, France.)]

- Bollerslev, Hood, Huss, and Pedersen (2016) show that under the assumption that the conditional Sharpe ratio is constant, investor's optimal position is equal to the proportion of Sharpe ratio to the expected volatility and it depends on the volatility and not on the expected returns:

- $x_t = \dfrac{SR/\gamma}{\sqrt{E_t(RV_{t+1})}}$, where SR is the constant conditional Sharpe ratio defined as $SR \equiv \dfrac{E_t(r^e_{t+1})}{\sqrt{E_t(RV_{t+1})}}$, γ is the risk aversion of the investor, $E_t(RV_{t+1})$ is the predicted volatility, and $E_t(r^e_{t+1})$ is the expected excess return.

- The framework give us the opportunity to describe the risk targeting behavior of investors since if they target to a constant volatility of $\sigma_{target} = SR/\gamma$, x_t is greater (lower) than 1 when $E_t(RV_{t+1})$ is below (above) σ_{target}.

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- Barroso and Santa-Clara (2015, Journal of Financial Economics) scale the US momentum factor by its six months realized volatility.

Portfolio	Maximum	Minimum	Mean	Standard deviation	Kurtosis	Skewness	Sharpe ratio	Information ratio
WML	26.18	-78.96	14.46	27.53	18.24	-2.47	0.53	—
WML^*	21.95	-28.40	16.50	16.95	2.68	-0.42	0.97	0.78

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Panel A: Risk−managed momentum: 1930:01 to 1939:12
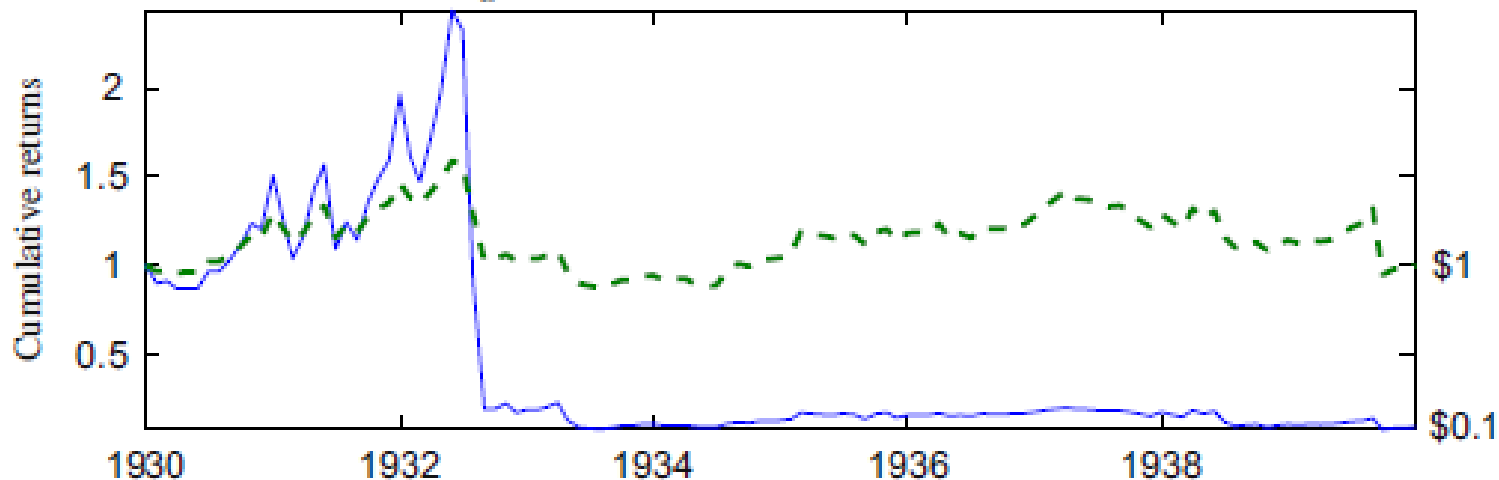
Panel B: Risk−managed momentum: 2000:01 to 2009:12
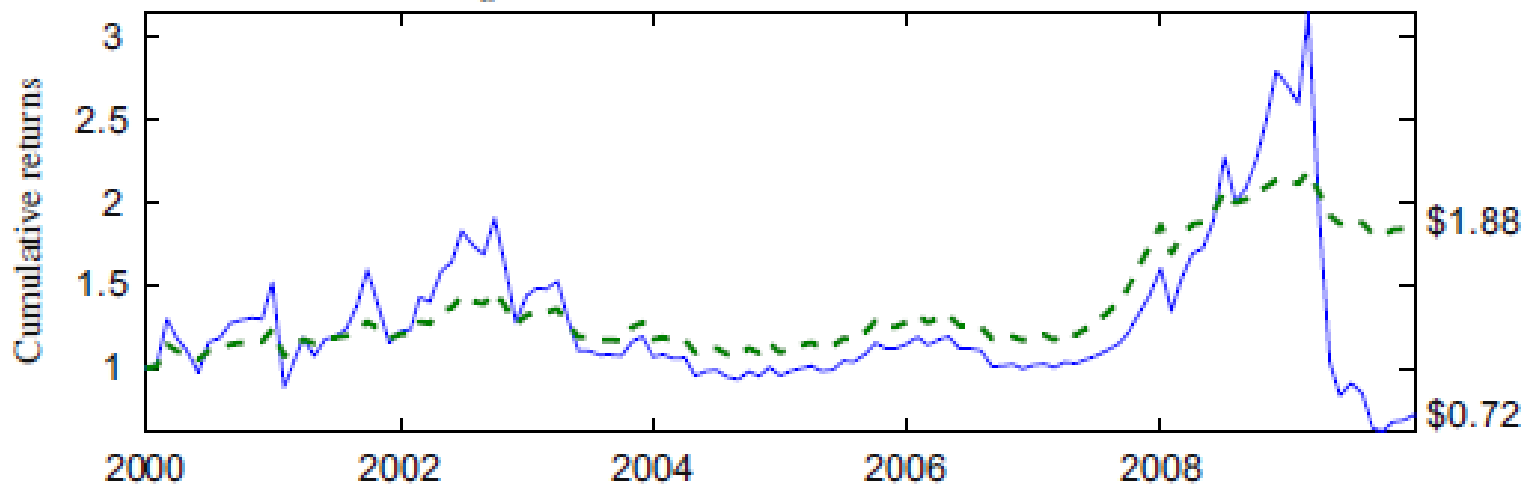
WML ——— WML*

- Moreira and Muir (2017, Journal of Finance) show that targeting volatility works for the market, value, momentum, profitability, return on equity, and investment factors.

	(1) Mkt$^\sigma$	(2) SMB$^\sigma$	(3) HML$^\sigma$	(4) Mom$^\sigma$	(5) RMW$^\sigma$	(6) CMA$^\sigma$	(7) FX$^\sigma$	(8) ROE$^\sigma$	(9) IA$^\sigma$
MktRF	0.61 (0.05)								
SMB		0.62 (0.08)							
HML			0.57 (0.07)						
Mom				0.47 (0.07)					
RMW					0.62 (0.08)				
CMA						0.68 (0.05)			
Carry							0.71 (0.08)		
ROE								0.63 (0.07)	
IA									0.68 (0.05)
Alpha (α)	4.86 (1.56)	-0.58 (0.91)	1.97 (1.02)	12.51 (1.71)	2.44 (0.83)	0.38 (0.67)	2.78 (1.49)	5.48 (0.97)	1.55 (0.67)
N	1,065	1,065	1,065	1,060	621	621	360	575	575
R^2	0.37	0.38	0.32	0.22	0.38	0.46	0.33	0.40	0.47
rmse	51.39	30.44	34.92	50.37	20.16	17.55	25.34	23.69	16.58

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- Extend the sample!!!

  – Using data from other major stock markets minimizes the biases that arise due to data snooping (Lo and MacKinlay, 1990) and offers an independent assessment of the empirical findings.

  – Analyze the Global SMB, HML, RMW, CMA, and WML factors

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	MKT	SMB	HML	RMW	CMA	WML
			Panel A. Static			
			Sharpe Ratios			
Global	0.44	0.27	0.50	0.78	0.45	0.55
Global ex US	0.31	0.28	0.68	0.82	0.38	0.69
Europe	0.40	0.15	0.50	0.91	0.39	0.80
Japan	0.09	0.21	0.44	0.15	0.11	0.11
Asia ex Japan	0.46	-0.09	0.75	0.24	0.53	0.64
NA	0.59	0.24	0.23	0.46	0.36	0.41
US	0.59	0.24	0.30	0.42	0.40	0.35
			Panel B. Volatility Managed			
			Sharpe Ratios			
Global	0.56	0.23	0.56	0.87	0.37	1.05***
Global ex US	0.36	0.25	0.75	0.86	0.38	1.18**
Europe	0.56*	0.13	0.56	1.08**	0.22	1.45**
Japan	0.06	0.19	0.43	0.13	0.20	0.18
Asia ex Japan	0.56	-0.08	0.88**	0.16	0.63	1.22***
NA	0.76	0.22	0.19	0.47	0.25	0.90***
US	0.76	0.22	0.33	0.46	0.33	0.78**
			Alpha			
Global	0.41	-0.24	2.13**	1.17**	1.35**	6.58***
Global ex US	-0.03	0.17	0.62	0.29	1.00	6.08***
Europe	0.39	0.08	1.11	1.09**	0.44	10.05***
Japan	-0.94	-0.08	-0.01	-0.18	0.95	0.53
Asia ex Japan	-0.33	0.35	1.48*	-0.43	1.79**	8.24***
NA	1.43	-0.59	2.56**	1.03	1.53	7.66***
US	1.17	-0.69	2.33*	1.43	0.77	7.11***

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- Contribution?

  - Replication …

- Quit?

  - Never!!!

- Contribution?

  – Replication …

- Quit?

  – Never!!!

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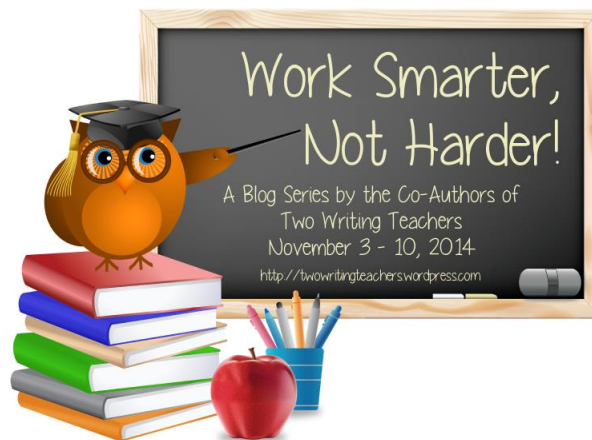
- Long-only positions
    - These factors are not investable as they ignore stock liquidity, transaction costs, and risk constraints, issues that are important for portfolio managers.

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	Panel A. Size – BM Portfolios					
	SMALL LoBM	ME1 BM2	SMALL HiBM	BIG LoBM	ME2 BM2	BIG HiBM
Global	-0.77	0.29	0.92	-0.52	0.60	0.88
Global ex US	0.61	1.03	0.32	-0.14	-0.21	0.10
Europe	1.11	1.83	2.40	0.10	-0.05	0.57
Japan	0.80	0.10	-0.77	-0.51	-0.89	-1.74
Asia ex Japan	0.38	0.87	4.36**	-0.16	-0.73	-0.43
NA	-2.13	0.60	3.02	0.47	2.13	2.32
US	-1.51	1.69	3.67	0.75	1.92	2.53
	Panel B. Size – Operating Profitability Portfolios					
	SMALL LoOP	ME1 OP2	SMALL HiOP	BIG LoOP	ME2 OP2	BIG HiOP
Global	0.07	0.49	1.16	-1.20	0.76	0.78
Global ex US	0.69	0.54	0.95	-1.00	0.00	0.35
Europe	1.88	1.92	2.58	-1.07	0.38	0.75
Japan	-0.35	-0.26	-0.62	-1.18	-0.98	-0.48
Asia ex Japan	3.78	1.71	1.01	-0.36	0.22	-0.77
NA	0.49	1.30	1.60	1.01	1.80	1.45
US	-0.43	1.47	0.73	0.64	1.53	1.35
	Panel C. Size – Investment Portfolios					
	SMALL LoINV	ME1 INV2	SMALL HiINV	BIG LoINV	ME2 INV2	BIG HiINV
Global	0.02	0.66	0.41	0.09	0.52	0.21
Global ex US	0.05	0.54	1.15	-0.16	-0.35	-0.04
Europe	1.41	1.79	2.44	0.24	0.01	0.49
Japan	-0.50	-0.25	0.08	-0.49	-1.10	-0.82
Asia ex Japan	3.93*	2.25	1.29	-0.59	-0.36	-0.42
NA	1.97	1.86	-0.79	1.59	1.80	0.72
US	1.44	1.93	-0.58	1.23	1.56	1.17
	Panel D. Size - Momentum					
	SMALL LoPRIOR	ME1 PRIOR2	SMALL HiPRIOR	BIG LoPRIOR	ME2 PRIOR2	BIG HiPRIOR
Global	-4.46**	0.40	2.62*	-1.94	0.75	1.52
Global ex US	-3.31**	0.41	2.12*	-2.88	-0.02	1.85
Europe	-3.98	1.90	3.89***	-2.94	0.54	3.08**
Japan	-2.36	-0.07	0.61	-3.32**	-0.64	0.81
Asia ex Japan	-6.02*	2.02	6.69***	-4.57	-0.14	2.15
NA	-4.35	2.00	3.13	0.20	1.91	2.39
US	-6.40**	1.43	2.60	-0.81	1.12	1.75

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- Contribution?
    - Extended sample
    - Long-only position
        - Volatility timing does not work for long-only positions!
- Ok, most likely we will publish the paper, but
    - We will not publish it at a top journal!

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- Which component drives the superior performance of the scaled factors?

HML

	Total	Small	Large	Long	Short	Small LoBM	Small HiBm	Big LowBM	Big HiBM
Alpha	1.67**	1.82***	-0.15	-1.73	3.41***	-2.72***	-0.90	-0.68	-0.83
Contribution		108.99%	-8.99%	-103.70%	203.70%	162.99%	-54.00%	40.71%	-49.70%

RMW

	Total	Small	Large	Long	Short	Small LoOP	Small HiOP	Big LowOP	Big HiOP
Alpha	1.88***	1.39***	0.49	-2.17*	4.05***	-3.05***	-1.67**	-1.00	-0.51
Contribution		73.82%	26.18%	-115.74%	215.74%	162.50%	-88.68%	53.24%	-27.06%

CMA

	Total	Small	Large	Long	Short	Small LoINV	Small HiINV	Big LowINV	Big HiINV
Alpha	1.22**	1.66***	-0.44	-2.96***	4.18***	-1.51**	-3.17***	-1.45***	-1.01*
Contribution		135.78%	-35.78%	-241.57%	341.57%	-123.42%	259.20%	-118.15%	82.37%

WML

	Total	Small	Large	Long	Short	Small LoPrior	Small HiPrior	Big LowPrior	Big HiPrior
Alpha	6.51***	5.45***	1.06	0.80	5.72***	-4.78***	0.67	-0.93	0.13
Contribution		83.72%	16.28%	12.22%	87.78%	73.45%	10.28%	14.33%	1.95%

- The risk-scaling strategy always works for the momentum factor, while for the value, operating, and investment factors the results are mixed since they depend on the sample period and the market.

- Their superior performance, however, is driven by the small capitalization stocks and in some cases by the short leg of the factor.

- Managing the volatility of the long-only style portfolios does not improve the return-to-risk ratios significantly.

- Our results suggest that volatility timing may be beneficial for asset managers who can hold long and short positions in small-capitalization stocks and it does not lead to significant gains when we use real-life investable portfolios.

- First, we develop a method to decompose the performance of the risk-scaled factors to its constituents (small, large, long, and short legs).

  – If the superior performance statistics of the risk-scaled factors are attributed to either the small or the short leg of the factors, investors would not be able to access these premiums due to liquidity, transaction costs, and risk constraints.

- Second, in line with the current practice of institutional investors, we focus also on the risk-scaled long-only style portfolios, and extend the literature since Barroso and Santa-Clara (2015) and Moreira and Muir (2017) examine the performance of the long/short volatility-managed factors.

- Third, we apply the risk scaling strategy to an extended universe of markets to investigate whether the reported findings that are based on the US market hold also for other.

- We use the US capitalization weighted daily and monthly returns of Fama and French (1993), Fama and French (2015) and Carhart (1997) factors for the period from January 1964 to December 2017

  - MKTRF, SMB, HML, RMW, CMA, WML

- We also from Kenneth French's database the six US portfolios formed on size and book-to-market, size and operating profitability, size and investment, and size and momentum.

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- The volatility-managed portfolio (r^*_{t+1}) is calculated as:

- $r^*_{t+1} = \frac{\sigma_{target}}{\hat{\sigma}_t} r_{t+1}$, where r_{t+1} is the static (raw) portfolio.

- The choice of the volatility target does not affect the Sharpe ratio of the risk-managed portfolios and hence for each factor, we set ex post σ_{target} to produce a risk-managed portfolio with the same volatility of that of the raw.

- Following the work of Barroso and Santa-Clara (2015) we use a six month period (126 daily observations) of daily returns to compute $\hat{\sigma}_t$.

- We evaluate the performance of the volatility-managed portfolios by using the Sharpe ratio, the risk-adjusted alpha, the appraisal ratio, and the breakeven transaction costs that offset the potential benefits of the strategies.

- We also evaluate the strategy by estimating the following equation:

- $r_t^* = \alpha + bMKT_t + sSMB_t + hHMLO_t + rRMW_t + cCMA_t + wWML_t + \varepsilon_t,$

- where $HMLO$ is the orthogonal HML defined as the sum of the intercept and the residual of the regression of HML on $MKT, SMB, RMW, CMA,$ and WML (Fama and French, 2015).

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- To study whether the long-only style portfolios outperform the unmanaged, we follow the framework of Angelidis, Giamouridis, and Tessaromatis (2013, Journal of Banking and Finance) who develop a methodology that evaluates the performance of mutual fund manages against their benchmark (in our case the static portfolios).

- We first estimate the following equation:

- $r_t^{\mathrm{x}} = \alpha^x + b^x r_t + \varepsilon_t^x.$

- Then we calculate the sum of the intercept (α^x) and the residuals (ε_t^x) of the regression which produces the realized excess returns ($r_t^{\mathrm{x,e}} = r_t^{\mathrm{x}} -$

- To illustrate what α^e, b^e, s^e, h^e, r^e, c^e, and w^e measure, assume that the volatility-managed long-only (r_t^{vm}) and the static (r_t^s) portfolios are described by the six-factor model:

- $r_t^{\mathrm{vm}} = \alpha^{vm} + b^{vm}MKT_t + s^{vm}SMB_t + h^{vm}HMLO_t + r^{vm}RMW_t + c^{vm}CMA_t + w^{vm}WML_t + \varepsilon_t^{vm},$

- $r_t^s = \alpha^s + b^s MKT_t + s^s SMB_t + h^s HMLO_t + r^s RMW_t + c^s CMA_t + w^s WML_t + \varepsilon_t^s.$

- If we multiple the former equation with b^x and substract it from the latter, we get:

- $r_t^{\mathrm{vm}} - b^x r_t^s = r_t^{\mathrm{x,e}} = \alpha^{vm} - b^x \alpha^s + (b^{vm} - b^x b^s)MKT_t + (s^{vm} -$

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	MKT	SMB	HML	RMW	CMA	WML
			Panel A. Static			
Average Return	6.31	3.14	4.14	2.96	3.51	7.87
Volatility	15.25	10.52	9.77	7.69	6.97	14.59
Sharpe Ratio	0.41	0.30	0.42	0.39	0.50	0.54
Minimum	-23.24	-14.85	-11.10	-18.72	-6.87	-34.39
Maximum	16.10	18.27	12.90	13.51	9.58	18.36
Skewness	-0.54	0.37	0.07	-0.31	0.29	-1.33
kurtosis	5.00	6.16	5.06	15.59	4.62	13.55
			Panel B. Volatility Managed			
Average Return	6.09	2.75	4.27	3.39	3.61	13.76
Volatility	15.25	10.52	9.77	7.69	6.97	14.59
Minimum	-22.28	-12.16	-10.08	-11.64	-6.47	-15.93
Maximum	12.73	10.96	12.72	7.43	6.11	17.91
Skewness	-0.59	0.15	0.15	-0.14	0.17	-0.11
Kurtosis	4.69	4.50	3.99	4.22	2.94	4.74
Sharpe Ratio	0.40	0.26	0.44	0.44	0.52	0.94***
Alpha	-1.71*	-0.80	1.67**	1.88***	1.22**	6.51***
Appraisal Ratio	-0.33	-0.21	0.42	0.53	0.46	0.87
Turnover	85.72%	80.03%	91.31%	88.78%	83.08%	131.20%
Break Even	-2.00%	-1.00%	1.83%	2.12%	1.47%	4.96%

- To formally investigate whether the outperformance of the factors is attributed to the small capitalization stocks, we estimate a regression of each component multiplied by the monthly weight $\left(\frac{\sigma_{target}}{\hat{\sigma}_t}\right)$ on $MKT, SMB, \text{HMLO}, RMW, CMA,$ and WML in order to decompose the alpha.

- Specifically, for each of the four portfolios components $(SmallLow, SmallHigh, BigLow, BigHigh)$ of the factors we estimate the following equations:

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- $\left(\frac{\sigma_{target}}{\hat{\sigma}_t}\right) SmallLow_t = \alpha_{SmallLow} + bMKT_t + sSMB_t + hHMLO_t + rRMW_t + cCMA_t + wWML_t + \varepsilon_t,$

- $\left(\frac{\sigma_{target}}{\hat{\sigma}_t}\right) SmallHigh_t = \alpha_{SmallHigh} + bMKT_t + sSMB_t + hHMLO_t + rRMW_t + cCMA_t + wWML_t + \varepsilon_t,$

- $\left(\frac{\sigma_{target}}{\hat{\sigma}_t}\right) BigLow_t = \alpha_{BigLow} + bMKT_t + sSMB_t + hHMLO_t + rRMW_t + cCMA_t + wWML_t + \varepsilon_t,$

- $\left(\frac{\sigma_{target}}{\hat{\sigma}_t}\right) BigHigh_t = \alpha_{BigHigh} + bMKT_t + sSMB_t + hHMLO_t + rRMW_t + cCMA_t + wWML_t + \varepsilon_t.$

- $a = -\alpha_{SmallLow} + \alpha_{SmallHigh} - \alpha_{BigLow} + \alpha_{BigHigh}.$

- $(= \alpha_{SmallHigh} - \alpha_{SmallLow}),$ large $(= \alpha_{BigHigh} - \alpha_{Biglow}),$ long $(=$

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	Total	Small	Large	Long	Short	Small LoBM	Small HiBm	Big LowBM	Big HiBM
					HML				
Alpha	1.67**	1.82***	-0.15	-1.73	3.41***	-2.72***	-0.90	-0.68	-0.83
Contribution		108.99%	-8.99%	-103.70%	203.70%	162.99%	-54.00%	40.71%	-49.70%

	Total	Small	Large	Long	Short	Small LoOP	Small HiOP	Big LowOP	Big HiOP
					RMW				
Alpha	1.88***	1.39***	0.49	-2.17*	4.05***	-3.05***	-1.67**	-1.00	-0.51
Contribution		73.82%	26.18%	-115.74%	215.74%	162.50%	-88.68%	53.24%	-27.06%

	Total	Small	Large	Long	Short	Small LoINV	Small HiINV	Big LowINV	Big HiINV
					CMA				
Alpha	1.22**	1.66***	-0.44	-2.96***	4.18***	-1.51**	-3.17***	-1.45***	-1.01*
Contribution		135.78%	-35.78%	-241.57%	341.57%	-123.42%	259.20%	-118.15%	82.37%

	Total	Small	Large	Long	Short	Small LoPrior	Small HiPrior	Big LowPrior	Big HiPrior
					WML				
Alpha	6.51***	5.45***	1.06	0.80	5.72***	-4.78***	0.67	-0.93	0.13
Contribution		83.72%	16.28%	12.22%	87.78%	73.45%	10.28%	14.33%	1.95%

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	SMALL LoBM	ME1 BM2	SMALL HiBM	BIG LoBM	ME2 BM2	BIG HiBM
Panel A. Size – BM Portfolios						
Sharpe Ratio	0.27	0.57	0.64	0.39	0.44	0.51
Volatility Managed						
Sharpe Ratio	0.19	0.50	0.61	0.39	0.43	0.52
Alpha	-5.05***	-1.90	-0.40	-1.31	-0.94	-0.80
Turnover	94.1%	90.4%	96.8%	88.5%	84.9%	84.9%

	SMALL LoOP	ME1 OP2	SMALL HiOP	BIG LoOP	ME2 OP2	BIG HiOP
Panel B. Size – Operating Profitability Portfolios						
Sharpe Ratio	0.33	0.56	0.55	0.29	0.38	0.48
Volatility Managed						
Sharpe Ratio	0.27	0.49	0.46	0.31	0.36	0.50
Alpha	-4.02***	-1.77	-2.33*	-3.07***	-1.81*	-0.46
Turnover	95.9%	87.5%	90.1%	87.2%	86.1%	85.7%

	SMALL LoINV	ME1 INV2	SMALL HiINV	BIG LoINV	ME2 INV2	BIG HiINV
Panel C. Size – Investment Portfolios						
Sharpe Ratio	0.55	0.63	0.30	0.54	0.47	0.32
Volatility Managed						
Sharpe Ratio	0.48	0.57	0.23	0.50	0.45	0.35
Alpha	-2.39*	-1.28	-4.04***	-0.94	-1.00	-2.11**
Turnover	93.3%	90.7%	92.5%	82.5%	84.0%	89.5%

	SMALL LoPRIOR	ME1 PRIOR2	SMALL HiPRIOR	BIG LoPRIOR	ME2 PRIOR2	BIG HiPRIOR
Panel D. Size - Momentum						
Sharpe Ratio	0.15	0.55	0.67	0.20	0.37	0.56
Volatility Managed						
Sharpe Ratio	-0.01*	0.48	0.64	0.18	0.33	0.60
Alpha	-9.63***	-2.20*	-0.70	-4.09**	-1.60*	0.49
Turnover	110.4%	95.1%	96.5%	111.4%	88.6%	89.1%

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- We use investible factor and style indices to investigate whether the volatility-managed strategy can generate excess returns under a practical investment framework.

  - The Fama-French portfolios are not investable and institutional investors cannot replicate.

  - For example, on December 2017 the small (large) capitalization-Low (high) momentum portfolio contains 954 (345) stocks with an average capitalization of 520 (35,290).

- For this reason, we use the (1) DJ thematic market neutral total return indices, and (2) MSCI style indices to examine if institutional investors can take advantage the academic evidence on managing the volatility of factor and style portfolios.

	Panel A. DJ Thematic Indices			
	DJ US thematic market neutral size	DJ US thematic market neutral value	DJ US thematic market neutral quality	DJ US thematic market neutral momentum
Sharpe Ratio	0.25	0.41	0.03	-0.11
	Volatility-Managed			
Sharpe Ratio	0.07	0.23	0.27	0.39
Alpha	-0.97	-1.67	0.89	5.87**
Appraisal Ratio	-0.35	-0.45	0.24	0.81
Turnover	73.67%	91.80%	90.27%	141.66%
Break Even	-2.04%	1.56%	3.80%	3.58%

	Factor Indices				
	SMB	HML	RMW	CMA	WML
Sharpe Ratio	0.25	-0.11	0.60	0.13	-0.06
	Volatility-Managed				
Sharpe Ratio	0.21	-0.09	0.49	0.11	0.41
Alpha	0.25	0.74	-0.88*	-0.26	6.35**
Appraisal Ratio	0.13	0.16	-0.66	-0.23	0.70
Turnover	78.03%	91.75%	67.36%	61.80%	162.61%
Break Even	0.32%	0.81%	-1.31%	-0.42%	3.91%

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	USA EQUAL WEIGHTED Standard (Large+Mid Cap) Equal Weighted	USA VALUE WEIGHTED Standard (Large+Mid Cap) Value Weighted	USA QUALITY Standard (Large+Mid Cap) Quality	USA MOMENTUM Standard (Large+Mid Cap) Momentum
	Panel A. MSCI Indices			
Sharpe Ratio	0.67	0.63	0.71	0.75
	Volatility - Managed			
Sharpe Ratio	0.71	0.70	0.75	0.84
Alpha	-0.46	0.05	-0.08	1.11
Turnover	81.91%	80.85%	78.23%	79.02%

	(SMALL LoBM+ ME1 BM2+ SMALL HiBM)/3	BIG HiBM	BIG HiOP	BIG LoINV	BIG HiPRIOR
	Panel B. Style FF Indices				
Sharpe Ratio	0.58	0.56	0.60	0.67	0.63
	Volatility – Managed				
Sharpe Ratio	0.58	0.66	0.62	0.70	0.69
Alpha	-1.35	0.57	-0.34	-0.08	0.59
Turnover	81.73%	82.72%	78.13%	78.68%	78.16%

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	Total	Small	Large	Long	Short	Small LoBM	Small HiBm	Big LowBM	Big HiBM
					HML				
Alpha	1.82**	2.01***	-0.18	2.29	-0.46	-0.62	1.39	1.08*	0.90
Contribution		110.10%	-10.10%	125.48%	-25.48%	33.90%	76.20%	-59.38%	49.27%

	Total	Small	Large	Long	Short	Small LoPrior	Small HiPrior	Big LowPrior	Big HiPrior
					WML				
Alpha	6.22***	4.80***	1.42*	3.86**	2.36	-2.52**	2.28**	0.16	1.58*
Contribution		77.23%	22.77%	62.01%	37.99%	40.57%	36.66%	-2.58%	25.35%

	SMALL LoBM	ME1 BM2	SMALL HiBM	BIG LoBM	ME2 BM2	BIG HiBM
			Panel A. Size – BM Portfolios			
Sharpe Ratio	0.32	0.49	0.51	0.42	0.42	0.45
			Volatility Managed			
Sharpe Ratio	0.35	0.55	0.62	0.51	0.56*	0.57*
Alpha	-0.40***	1.77	4.00***	0.85	1.92	2.41
Turnover	120.1%	124.4%	137.5%	101.6%	114.1%	119.9%

	SMALL LoPRIOR	ME1 PRIOR2	SMALL HiPRIOR	BIG LoPRIOR	ME2 PRIOR2	BIG HiPRIOR
			Panel B. Size - Momentum			
Sharpe Ratio	0.21	0.48	0.64	0.18	0.39	0.59
			Volatility Managed			
Sharpe Ratio	0.14	0.56	0.73	0.24	0.49	0.71**
Alpha	-5.50***	2.01	4.15***	-1.37	0.63	3.20***
Turnover	143.8%	137.7%	126.4%	145.8%	116.9%	108.1%

HML	Total	Small	Large	Long	Short	Small LoBM	Small HiBm	Big LowBM	Big HiBM
Alpha	2.36	1.82**	0.54	4.91	-2.55	0.70	2.52	1.86	2.40
Contribution		77.08%	22.92%	208.30%	-108.30%	-29.58%	106.65%	-78.72%	101.64%
WML	Total	Small	Large	Long	Short	Small LoPrior	Small HiPrior	Big LowPrior	Big HiPrior
Alpha	6.99***	3.58***	3.41***	4.73	2.26	-0.95	2.63	-1.32	2.09
Contribution		51.26%	48.74%	67.61%	32.39%	13.56%	37.69%	18.82%	29.92%

Size – BM Portfolios

	SMALL LoBM	ME1 BM2	SMALL HiBM	BIG LoBM	ME2 BM2	BIG HiBM
Sharpe Ratio	0.39	0.45	0.46	0.46	0.43	0.44

Volatility Managed

Sharpe Ratio	0.57	0.63	0.64	0.64	0.72	0.64
Alpha	3.56	4.44	6.23*	2.14	4.72*	4.04

Panel B. Size - Momentum

	SMALL LoPRIOR	ME1 PRIOR2	SMALL HiPRIOR	BIG LoPRIOR	ME2 PRIOR2	BIG HiPRIOR
Sharpe Ratio	0.28	0.46	0.62	0.17	0.43	0.64

Volatility Managed

Sharpe Ratio	0.36	0.68*	0.86**	0.31	0.68*	0.86**
Alpha	-2.02	5.52	8.13**	-2.72	2.79	5.64***

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	MKT	SMB	HML	RMW	CMA	WML
			Panel A. Static			
			Sharpe Ratios			
Global	0.44	0.27	0.50	0.78	0.45	0.55
Global ex US	0.31	0.28	0.68	0.82	0.38	0.69
Europe	0.40	0.15	0.50	0.91	0.39	0.80
Japan	0.09	0.21	0.44	0.15	0.11	0.11
Asia ex Japan	0.46	-0.09	0.75	0.24	0.53	0.64
NA	0.59	0.24	0.23	0.46	0.36	0.41
US	0.59	0.24	0.30	0.42	0.40	0.35
			Panel B. Volatility Managed			
			Sharpe Ratios			
Global	0.56	0.23	0.56	0.87	0.37	1.05***
Global ex US	0.36	0.25	0.75	0.86	0.38	1.18**
Europe	0.56*	0.13	0.56	1.08**	0.22	1.45**
Japan	0.06	0.19	0.43	0.13	0.20	0.18
Asia ex Japan	0.56	-0.08	0.88**	0.16	0.63	1.22***
NA	0.76	0.22	0.19	0.47	0.25	0.90***
US	0.76	0.22	0.33	0.46	0.33	0.78**
			Alpha			
Global	0.41	-0.24	2.13**	1.17**	1.35**	6.58***
Global ex US	-0.03	0.17	0.62	0.29	1.00	6.08***
Europe	0.39	0.08	1.11	1.09**	0.44	10.05***
Japan	-0.94	-0.08	-0.01	-0.18	0.95	0.53
Asia ex Japan	-0.33	0.35	1.48*	-0.43	1.79**	8.24***
NA	1.43	-0.59	2.56**	1.03	1.53	7.66***
US	1.17	-0.69	2.33*	1.43	0.77	7.11***

	SMALL LoBM	ME1 BM2	SMALL HiBM	BIG LoBM	ME2 BM2	BIG HiBM
Global	-0.77	0.29	0.92	-0.52	0.60	0.88
Global ex US	0.61	1.03	0.32	-0.14	-0.21	0.10
Europe	1.11	1.83	2.40	0.10	-0.05	0.57
Japan	0.80	0.10	-0.77	-0.51	-0.89	-1.74
Asia ex Japan	0.38	0.87	4.36**	-0.16	-0.73	-0.43
NA	-2.13	0.60	3.02	0.47	2.13	2.32
US	-1.51	1.69	3.67	0.75	1.92	2.53

Panel B. Size – Operating Profitability Portfolios

	SMALL LoOP	ME1 OP2	SMALL HiOP	BIG LoOP	ME2 OP2	BIG HiOP
Global	0.07	0.49	1.16	-1.20	0.76	0.78
Global ex US	0.69	0.54	0.95	-1.00	0.00	0.35
Europe	1.88	1.92	2.58	-1.07	0.38	0.75
Japan	-0.35	-0.26	-0.62	-1.18	-0.98	-0.48
Asia ex Japan	3.78	1.71	1.01	-0.36	0.22	-0.77
NA	0.49	1.30	1.60	1.01	1.80	1.45
US	-0.43	1.47	0.73	0.64	1.53	1.35

Panel C. Size – Investment Portfolios

	SMALL LoINV	ME1 INV2	SMALL HiINV	BIG LoINV	ME2 INV2	BIG HiINV
Global	0.02	0.66	0.41	0.09	0.52	0.21
Global ex US	0.05	0.54	1.15	-0.16	-0.35	-0.04
Europe	1.41	1.79	2.44	0.24	0.01	0.49
Japan	-0.50	-0.25	0.08	-0.49	-1.10	-0.82
Asia ex Japan	3.93*	2.25	1.29	-0.59	-0.36	-0.42
NA	1.97	1.86	-0.79	1.59	1.80	0.72
US	1.44	1.93	-0.58	1.23	1.56	1.17

Panel D. Size - Momentum

	SMALL LoPRIOR	ME1 PRIOR2	SMALL HiPRIOR	BIG LoPRIOR	ME2 PRIOR2	BIG HiPRIOR
Global	-4.46**	0.40	2.62*	-1.94	0.75	1.52
Global ex US	-3.31**	0.41	2.12*	-2.88	-0.02	1.85
Europe	-3.98	1.90	3.89***	-2.94	0.54	3.08**
Japan	-2.36	-0.07	0.61	-3.32**	-0.64	0.81
Asia ex Japan	-6.02*	2.02	6.69***	-4.57	-0.14	2.15
NA	-4.35	2.00	3.13	0.20	1.91	2.39
US	-6.40**	1.43	2.60	-0.81	1.12	1.75

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- Volatility targeting, a strategy that increases (decreases) the current portfolio weights if the historical volatility is lower (higher) than the target volatility, it may produce significant risk-adjusted alphas and higher Sharpe ratios than a static position.

- We demonstrate that it can be extremely beneficial for investors who can hold long and short positions in **small** capitalization stocks, but it does not reward them when we consider either long-only portfolios or investable indices.

- Why volatility targeting does not work for small capitalization stocks?

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Thank you!

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