This appendix provides empirical results and discussions on the performance of volatility-timing strategies applied to the Fama-French size and value factors. Below we briefly describe the contents of the appendix.

- Appendix A: Performance of Volatility-Timing Strategies for Size and Value Factors
- Table A.1: In-Sample Performance of Volatility-Managed Portfolio for Size Factor
- Table A.2: Out-of-Sample Performance of Volatility-Managed Portfolio for Size Factor
- Table A.3: Performance of Volatility Targeting for Size Factor
- Table A.4: Performance of Portfolio Allocation Under Estimation Risk for Size Factor
- Table A.5: Performance of Unconditional Optimal Portfolio with Conditional Information for Size Factor
- Table A.6: In-Sample Performance of Volatility-Managed Portfolio for Value Factor
- Table A.7: Out-of-Sample Performance of Volatility-Managed Portfolio for Value Factor
- Table A.8: Performance of Volatility Targeting for Value Factor
- Table A.9: Performance of Portfolio Allocation Under Estimation Risk for Value Factor
- Table A.10: Performance of Unconditional Optimal Portfolio with Conditional Information for Value Factor
A Performance of Volatility-Timing Strategies for Size and Value Factors

Here we examine the effect of volatility timing on other non-market factors. For brevity, we focus on the size factor of Fama and French (1993).

Table A.1 compares the performance of the size factor portfolio and the corresponding volatility-managed strategy of Moreira and Muir (2017) with $L$ estimated in-sample. The Sharpe ratio (SR) of the volatility-timing strategy over the full sample is 0.1027 under unlimited leverage and 0.1554 under limited leverage, both being lower than the SR of the size factor itself, which is 0.2302. The subsample results show that the SR of the volatility-timing strategy is consistently lower in all subperiods. In particular, from 1961 to 1980 the difference in the SR between the volatility-timing strategy with unlimited leverage and the size portfolio is economically large (0.1403 vs. 0.4316) and significant at the 10% level. In addition, volatility timing also increases the maximum drawdown (MDD), with the largest decline being 0.7154 without leverage constraint and 0.5336 with leverage constraint. Both are substantially larger than the MDD of the size factor itself, which is only 0.3133.

Table A.2 reports performance of the volatility-timing strategy of Moreira and Muir (2017) applied to the size factor with $L$ estimated out-of-sample. Based on both 10-year fixed-window and 10-year rolling-window estimation of $L$, the SR of the volatility-timing strategy is lower than that of the original size factor for the full sample as well as for most subsamples. This difference is even statistically significant in some cases. Under fixed-window estimation of $L$, the MDD 0.9993, meaning that the volatility-managed factor portfolio almost goes bankrupt. Under rolling-window estimation, the MDD is 0.3779, still larger than that of the size factor itself.

One silent feature is that the volatility-managed portfolio strategy can no longer improve the performance of the size factor during the last period including the financial crisis, in sharp contrast to the case on the market factor. Upon further examination, this seems expected. What drives the improvement in the market factor case is the extremely high volatility, making it effective to reduce risk exposure. This is exactly the idea of volatility timing that reduces weight when volatility is high. However, the volatility of size factor is fairly stable overtime. The highly stable volatility comes from the fact that it is a long-
short portfolio in which large losses of the long position are offset by large gains in the short position.

In summary, the performance of the volatility-timing strategy of Moreira and Muir (2017) on the size factor is worse than its performance on the market factor. The results are similar for value factor. In addition, the other three volatility-timing strategies also do not work. In short, all volatility-timing strategies do not improve the performance of major factor portfolios such as the size and value.

References


Table A.1: In-Sample Performance of Volatility-Managed Portfolio for Size Factor

This table reports summary statistics of the Fama-French size factor (Panel A) and the volatility-managed portfolio of Moreira and Muir (2017) applied to the size factor (Panel B) with the leverage parameter $L$ estimated in-sample. We report results for the full sample from August 1936 to December 2017 as well as for four different subsample periods. The summary statistics include the number of observations, mean, volatility, minimum, maximum, maximum drawdown (MDD), and the Sharpe ratio (SR). For the volatility-managed portfolio, we consider cases with unlimited leverage (UL) and limited leverage (LL) separately. We also report the risk-adjusted alpha of the volatility-managed portfolio with respect to the size factor and the difference in the Sharpe ratio between the volatility-managed portfolio and the size factor. Asterisks denote statistical significance based on Newey-West standard errors (for alpha) or HAC standard errors (for the Sharpe ratio test) at the 1% (***) and 10% (*) levels.

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Table A.2: Out-of-Sample Performance of Volatility-Managed Portfolio for Size Factor

This table reports summary statistics of the volatility-managed portfolio of Moreira and Muir (2017) applied to the Fama-French size factor with the leverage parameter $L$ estimated out-of-sample using a 10-year fixed training window (Panel A) and 10-year rolling windows (Panel B). We report results for the full sample from August 1936 to December 2017 as well as for four different subsample periods. We consider cases with unlimited leverage (UL) and limited leverage (LL) separately. The summary statistics include the number of observations, mean, volatility, minimum, maximum, maximum drawdown (MDD), and the Sharpe ratio (SR). We also report the risk-adjusted alpha of the volatility-managed portfolio with respect to the size factor and the difference in the Sharpe ratio between the volatility-managed portfolio and the size factor. Asterisks denote statistical significance based on Newey-West standard errors (for alpha) or HAC standard errors (for the Sharpe ratio test) at the 1% (***) and 5% (**) levels.

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Table A.3: Performance of Volatility Targeting for Size Factor

This table reports summary statistics of the volatility-targeting strategy of Barroso and Santa-Clara (2015) applied to the Fama-French size factor with annualized target volatility of 12% (Panel A), 16% (Panel B), and 20% (Panel C). We report results for the full sample from August 1936 to December 2017 as well as for four different subsample periods. We consider cases with unlimited leverage (UL) and limited leverage (LL) separately. The summary statistics include the number of observations, mean, volatility, minimum, maximum, maximum drawdown (MDD), and the Sharpe ratio (SR). We also report the risk-adjusted alpha of the volatility-targeting strategy with respect to the size factor and the difference in the Sharpe ratio between the volatility-targeting strategy and the size factor. Asterisks denote statistical significance based on Newey-West standard errors (for alpha) or HAC standard errors (for the Sharpe ratio test) at the 1% (***) , 5% (**) and 10% (*) levels.

### Panel A: Annualized Target Volatility 12%

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### Panel C: Annualized Target Volatility 20%

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Table A.4: Performance of Portfolio Allocation Under Estimation Risk for Size Factor

This table reports summary statistics of the mean-variance portfolio allocation strategy under estimation risk of Kan and Zhou (2007) applied to the Fama-French size factor with risk aversion levels of $A = 3$ (Panel A) and $A = 5$ (Panel B). We report results for the full sample from August 1936 to December 2017 as well as for four different subsample periods. We consider cases with unlimited leverage (UL) and limited leverage (LL) separately. The summary statistics include the number of observations, mean, volatility, minimum, maximum, maximum drawdown (MDD), and the Sharpe ratio (SR). We also report the risk-adjusted alpha of the portfolio allocation strategy with respect to the size factor and the difference in the Sharpe ratio between the portfolio allocation strategy and the size factor. Asterisks denote statistical significance based on Newey-West standard errors (for alpha) or HAC standard errors (for the Sharpe ratio test) at the 1% (***) , 5% (**) and 10% (*) levels.

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Table A.5: Performance of Unconditional Optimal Portfolio with Conditional Information for Size Factor

This table reports summary statistics of the unconditional optimal portfolio with conditional information of Ferson and Siegel (2001) applied to the Fama-French size factor with annualized target expected returns of 6% (Panel A) and 10% (Panel B). We report results for the full sample from August 1936 to December 2017 as well as for four different subsample periods. We consider cases with unlimited leverage (UL) and limited leverage (LL) separately. The summary statistics include the number of observations, mean, volatility, minimum, maximum, maximum drawdown (MDD), and the Sharpe ratio (SR). We also report the risk-adjusted alpha of the unconditional optimal portfolio with respect to the size factor and the difference in the Sharpe ratio between the unconditional optimal portfolio and the size factor. Asterisks denote statistical significance based on Newey-West standard errors (for alpha) or HAC standard errors (for the Sharpe ratio test) at the 1% (***) , 5% (**) and 10% (*) levels.

### Panel A: Annualized Target Expected Return 6%

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<td>-0.1356</td>
<td>0.0887</td>
<td>-0.4889**</td>
<td>-0.3924**</td>
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Table A.6: In-Sample Performance of Volatility-Managed Portfolio for Value Factor

This table reports summary statistics of the Fama-French value factor (Panel A) and the volatility-managed portfolio of Moreira and Muir (2017) applied to the value factor (Panel B) with the leverage parameter $L$ estimated in-sample. We report results for the full sample from August 1936 to December 2017 as well as for four different subsample periods. The summary statistics include the number of observations, mean, volatility, minimum, maximum, maximum drawdown (MDD), and the Sharpe ratio (SR). For the volatility-managed portfolio, we consider cases with unlimited leverage (UL) and limited leverage (LL) separately. We also report the risk-adjusted alpha of the volatility-managed portfolio with respect to the value factor and the difference in the Sharpe ratio between the volatility-managed portfolio and the value factor. Asterisks denote statistical significance based on Newey-West standard errors (for alpha) or HAC standard errors (for the Sharpe ratio test) at the 1% (***) , 5% (**) and 10% (*) levels.

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This table reports summary statistics of the volatility-managed portfolio of Moreira and Muir (2017) applied to the Fama-French value factor with the leverage parameter $L$ estimated out-of-sample using a 10-year fixed training window (Panel A) and 10-year rolling windows (Panel B). We report results for the full sample from August 1936 to December 2017 as well as for four different subsample periods. We consider cases with unlimited leverage (UL) and limited leverage (LL) separately. The summary statistics include the number of observations, mean, volatility, minimum, maximum, maximum drawdown (MDD), and the Sharpe ratio (SR). We also report the risk-adjusted alpha of the volatility-managed portfolio with respect to the value factor and the difference in the Sharpe ratio between the volatility-managed portfolio and the value factor. Asterisks denote statistical significance based on Newey-West standard errors (for alpha) or HAC standard errors (for the Sharpe ratio test) at the 1% (***) , 5% (**), and 10% (*) levels.

### Panel A: 10-Year Fixed Window

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### Panel B: 10-Year Rolling Window

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Table A.8: Performance of Volatility Targeting for Value Factor

This table reports summary statistics of the volatility-targeting strategy of Barroso and Santa-Clara (2015) applied to the Fama-French value factor with annualized target volatility of 12% (Panel A), 16% (Panel B), and 20% (Panel C). We report results for the full sample from August 1936 to December 2017 as well as for four different subsample periods. We consider cases with unlimited leverage (UL) and limited leverage (LL) separately. The summary statistics include the number of observations, mean, volatility, minimum, maximum, maximum drawdown (MDD), and the Sharpe ratio (SR). We also report the risk-adjusted alpha of the volatility-targeting strategy with respect to the value factor and the difference in the Sharpe ratio between the volatility-targeting strategy and the value factor. Asterisks denote statistical significance based on Newey-West standard errors (for alpha) or HAC standard errors (for the Sharpe ratio test) at the 1% (***) , 5% (**) and 10% (*) levels.

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<td>-0.0786 -0.0193</td>
<td>0.1005 0.0219</td>
<td>-0.0409 -0.0068</td>
<td>0.0934 0.0883</td>
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<td>0.0911 0.0545</td>
<td>0.0769 0.0446</td>
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<td>-0.2303 -0.1743</td>
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Table A.9: Performance of Portfolio Allocation Under Estimation Risk for Value Factor

This table reports summary statistics of the mean-variance portfolio allocation strategy under estimation risk of Kan and Zhou (2007) applied to the Fama-French value factor with risk aversion levels of $A = 3$ (Panel A) and $A = 5$ (Panel B). We report results for the full sample from August 1936 to December 2017 as well as for four different subsample periods. We consider cases with unlimited leverage (UL) and limited leverage (LL) separately. The summary statistics include the number of observations, mean, volatility, minimum, maximum, maximum drawdown (MDD), and the Sharpe ratio (SR). We also report the risk-adjusted alpha of the portfolio allocation strategy with respect to the value factor and the difference in the Sharpe ratio between the portfolio allocation strategy and the value factor. Asterisks denote statistical significance based on Newey-West standard errors (for alpha) or HAC standard errors (for the Sharpe ratio test) at the 1% (***)), 5% (**), and 10% (*) levels.

### Panel A: Risk Aversion $A = 3$

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### Panel B: Risk Aversion $A = 5$

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Table A.10: Performance of Unconditional Optimal Portfolio with Conditional Information for Value Factor

This table reports summary statistics of the unconditional optimal portfolio with conditional information of Ferson and Siegel (2001) applied to the Fama-French value factor with annualized target expected returns of 6% (Panel A) and 10% (Panel B). We report results for the full sample from August 1936 to December 2017 as well as for four different subsample periods. We consider cases with unlimited leverage (UL) and limited leverage (LL) separately. The summary statistics include the number of observations, mean, volatility, minimum, maximum, maximum drawdown (MDD), and the Sharpe ratio (SR). We also report the risk-adjusted alpha of the unconditional optimal portfolio with respect to the value factor and the difference in the Sharpe ratio between the unconditional optimal portfolio and the value factor. Asterisks denote statistical significance based on Newey-West standard errors (for alpha) or HAC standard errors (for the Sharpe ratio test) at the 1% (***) and 10% (*) levels.

### Panel A: Annualized Target Expected Return 6%

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<td>-0.0602</td>
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<td>-0.1401*</td>
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### Panel B: Annualized Target Expected Return 10%

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