

Online Appendix

to accompany

Arbitrage Asymmetry and the Idiosyncratic Volatility Puzzle

by

Robert F. Stambaugh, Jianfeng Yu, and Yu Yuan

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Table AI
Idiosyncratic Volatility Effects in Underpriced versus Overpriced Stocks for
Independently Sorted Portfolios (Newey-West Standard Errors, lag=3)

The table reports average benchmark-adjusted returns for portfolios formed by sorting stocks independently on the idiosyncratic volatility (IVOL) of their returns and the mispricing measure, as determined by an average of the rankings produced by 11 anomaly variables. Also reported are results based on sorting by IVOL within the entire stock universe. Benchmark-adjusted returns are calculated as a in the regression,

$$R_{i,t} = a + bMKT_t + cSMB_t + dHML_t + \epsilon_{i,t},$$

where $R_{i,t}$ is the excess percent return in month t . The sample period is from 8/1965 to 1/2011. All t-statistics (in parentheses) are based on the heteroskedasticity-consistent standard errors of Newey-West with lag = 3.

	Highest IVOL	Next 20%	Next 20%	Next 20%	Lowest IVOL	Highest –Lowest	All Stocks
Most overpriced (top 20%)	-1.89 (-10.93)	-0.95 (-6.91)	-0.72 (-4.93)	-0.47 (-3.44)	-0.39 (-2.90)	-1.50 (-6.56)	-0.81 (-7.75)
Next 20%	-0.88 (-5.75)	-0.41 (-3.53)	-0.31 (-3.03)	-0.21 (-2.15)	-0.04 (-0.44)	-0.84 (-4.23)	-0.23 (-3.98)
Next 20%	-0.09 (-0.51)	-0.01 (-0.09)	-0.05 (-0.51)	-0.12 (-1.46)	0.02 (0.17)	-0.10 (-0.52)	-0.07 (-1.64)
Next 20%	-0.15 (-0.76)	0.07 (0.63)	0.17 (1.95)	0.18 (2.52)	0.23 (3.13)	-0.38 (-1.79)	0.18 (4.43)
Most underpriced (bottom 20%)	0.56 (3.07)	0.68 (4.39)	0.51 (4.60)	0.33 (4.34)	0.14 (1.92)	0.41 (1.95)	0.28 (5.78)
Most overpriced – most underpriced	-2.44 (-10.55)	-1.63 (-8.84)	-1.23 (-6.43)	-0.81 (-4.97)	-0.53 (-3.55)	-1.91 (-7.40)	-1.09 (-7.92)
All stocks	-0.69 (-5.47)	-0.12 (-1.49)	-0.00 (-0.01)	0.05 (1.10)	0.08 (1.62)	-0.78 (-4.79)	

Table AII
Idiosyncratic Volatility Effects in Underpriced versus Overpriced Stocks for
Independent Sorted Portfolios (Newey-West Standard Errors, lag=6)

The table reports average benchmark-adjusted returns for portfolios formed by sorting stocks independently on the idiosyncratic volatility (IVOL) of their returns and the mispricing measure, as determined by an average of the rankings produced by 11 anomaly variables. Also reported are results based on sorting by IVOL within the entire stock universe. Benchmark-adjusted returns are calculated as a in the regression,

$$R_{i,t} = a + bMKT_t + cSMB_t + dHML_t + \epsilon_{i,t},$$

where $R_{i,t}$ is the excess percent return in month t . The sample period is from 8/1965 to 1/2011. All t-statistics (in parentheses) are based on the heteroskedasticity-consistent standard errors of Newey-West with lag = 6.

	Highest IVOL	Next 20%	Next 20%	Next 20%	Lowest IVOL	Highest –Lowest	All Stocks
Most overpriced (top 20%)	-1.89 (-10.19)	-0.95 (-6.77)	-0.72 (-4.99)	-0.47 (-3.59)	-0.39 (-2.77)	-1.50 (-6.03)	-0.81 (-7.90)
Next 20%	-0.88 (-5.71)	-0.41 (-3.67)	-0.31 (-3.07)	-0.21 (-2.29)	-0.04 (-0.44)	-0.84 (-4.14)	-0.23 (-4.17)
Next 20%	-0.09 (-0.53)	-0.01 (-0.10)	-0.05 (-0.49)	-0.12 (-1.50)	0.02 (0.17)	-0.10 (-0.52)	-0.07 (-1.63)
Next 20%	-0.15 (-0.74)	0.07 (0.63)	0.17 (2.05)	0.18 (2.55)	0.23 (2.88)	-0.38 (-1.80)	0.18 (4.31)
Most underpriced (bottom 20%)	0.56 (2.92)	0.68 (4.29)	0.51 (4.39)	0.33 (4.32)	0.14 (1.84)	0.41 (1.80)	0.28 (5.76)
Most overpriced – most underpriced	-2.44 (-10.32)	-1.63 (-8.71)	-1.23 (-6.52)	-0.81 (-5.13)	-0.53 (-3.48)	-1.91 (-6.98)	-1.09 (-8.01)
All stocks	-0.69 (-5.09)	-0.12 (-1.46)	-0.00 (-0.01)	0.05 (1.09)	0.08 (1.52)	-0.78 (-4.44)	

Table AIII
Idiosyncratic Volatility Effects in Underpriced versus Overpriced Stocks
for Equally Weighted Portfolios

The table reports average benchmark-adjusted returns for portfolios formed by sorting stocks independently on the idiosyncratic volatility (IVOL) of their returns and the mispricing measure, as determined by an average of the rankings produced by 11 anomaly variables. Also reported are results based on sorting by IVOL within the entire stock universe. Benchmark-adjusted returns are calculated as a in the regression,

$$R_{i,t} = a + bMKT_t + cSMB_t + dHML_t + \epsilon_{i,t},$$

where $R_{i,t}$ is the excess percent return in month t . The portfolio returns are equally weighted. The sample period is from 8/1965m8 to 1/2011. All t-statistics (in parentheses) are based on the heteroskedasticity-consistent standard errors of White (1980).

	Highest IVOL	Next 20%	Next 20%	Next 20%	Lowest IVOL	Highest –Lowest	All Stocks
Most overpriced (top 20%)	-1.80 (-16.19)	-0.87 (-9.81)	-0.53 (-5.91)	-0.42 (-4.71)	-0.29 (-3.11)	-1.51 (-9.58)	-0.99 (-13.09)
Next 20%	-0.74 (-7.93)	-0.18 (-2.35)	0.03 (0.43)	-0.01 (-0.18)	-0.03 (-0.42)	-0.70 (-5.42)	-0.20 (-4.03)
Next 20%	-0.22 (-2.42)	0.22 (3.45)	0.32 (5.04)	0.14 (2.15)	0.13 (2.09)	-0.35 (-2.82)	0.13 (3.34)
Next 20%	0.04 (0.42)	0.43 (6.61)	0.43 (6.72)	0.40 (6.41)	0.23 (3.81)	-0.19 (-1.55)	0.32 (7.75)
Most underpriced (bottom 20%)	0.59 (5.62)	0.78 (10.95)	0.74 (11.43)	0.53 (8.02)	0.36 (5.56)	0.23 (1.74)	0.58 (11.98)
Most overpriced – Most underpriced	-2.39 (-16.87)	-1.66 (-14.87)	-1.28 (-12.76)	-0.95 (-10.4)	-0.65 (-7.19)	-1.74 (-11.11)	-1.58 (-16.44)
All stocks	-0.69 (-9.25)	0.01 (0.16)	0.21 (3.97)	0.18 (3.12)	0.13 (2.34)	-0.83 (-7.27)	

Table AIV
Idiosyncratic Volatility Effects in Underpriced versus Overpriced Stocks for
Independently Double-Sorted Portfolios (Alternative Mispricing Measure)

The table reports average benchmark-adjusted returns for portfolios formed by sorting stocks independently on the idiosyncratic volatility (IVOL) of their returns and an alternative mispricing measure. The alternative measure is constructed by first using cluster analysis to separate the 11 anomalies into 5 groups: (Total accruals), (Net operating assets, Asset growth, Investments-to-Assets), (Failure probability, Momentum), (Ohlson's O-score, Gross profitability, Return on assets) and (Net stock issues, Composite equity issues). For each group, a ranking percentile is computed as the simple average of the ranking percentiles of the anomalies within the group. Then, each month, we estimate a cross-sectional regression of benchmark-adjusted individual stock returns on the five group-ranking percentiles (with missing ranking percentiles assigned a value of 50%), and the five-year rolling average of the resulting slope coefficients are used to weight anomalies in the alternative mispricing measure. Also reported are results based on sorting by IVOL within the entire stock universe. Benchmark-adjusted returns are calculated as a in the regression,

$$R_{i,t} = a + bMKT_t + cSMB_t + dHML_t + \epsilon_{i,t},$$

where $R_{i,t}$ is the excess percent return in month t . The sample period is from 8/1968 to 1/2011. All t-statistics (in parentheses) are based on the heteroskedasticity-consistent standard errors of White (1980).

	Highest IVOL	Next 20%	Next 20%	Next 20%	Lowest IVOL	Highest –Lowest	All Stocks
Most overpriced (top 20%)	-2.53 (-12.79)	-1.44 (-7.35)	-1.13 (-5.82)	-0.68 (-3.50)	-0.67 (-4.14)	-1.86 (-8.23)	-0.90 (-6.17)
Next 20%	-0.92 (-5.54)	-0.33 (-2.28)	-0.36 (-2.80)	-0.23 (-1.86)	-0.26 (-2.25)	-0.66 (-3.22)	-0.29 (-3.48)
Next 20%	-0.26 (-1.87)	-0.07 (-0.62)	-0.09 (-0.83)	-0.10 (-1.04)	-0.02 (-0.25)	-0.24 (-1.32)	-0.07 (-1.30)
Next 20%	-0.12 (-0.78)	0.09 (0.80)	0.08 (0.90)	0.08 (1.03)	0.11 (1.37)	-0.23 (-1.27)	0.09 (1.89)
Most underpriced (bottom 20%)	0.71 (3.49)	0.59 (3.65)	0.57 (4.98)	0.24 (2.32)	0.21 (2.39)	0.50 (2.40)	0.32 (4.13)
Most overpriced – Most underpriced	-3.24 (-10.95)	-2.04 (-6.81)	-1.70 (-6.61)	-0.92 (-3.52)	-0.88 (-4.16)	-2.36 (-8.43)	-1.22 (-5.86)
All stocks	-0.74 (-6.12)	-0.13 (-1.55)	-0.02 (-0.35)	0.05 (0.99)	0.08 (1.74)	-0.82 (-5.51)	

Table AV
Idiosyncratic Volatility Effects in Underpriced versus Overpriced Stocks
for Conditionally Double-Sorted Portfolios

The table reports average benchmark-adjusted returns for portfolios formed by sorting stocks on the idiosyncratic volatility (IVOL) of their returns. The sort on IVOL is performed for stocks within a given range of over/under-pricing, as determined by an average of the rankings produced by 11 anomaly variables. Also reported are results based on sorting by IVOL within the entire stock universe. Benchmark-adjusted returns are calculated as a in the regression,

$$R_{i,t} = a + bMKT_t + cSMB_t + dHML_t + \epsilon_{i,t},$$

where $R_{i,t}$ is the excess percent return in month t . The sample period is from 8/1965 to 1/2011. All t-statistics (in parentheses) are based on the heteroskedasticity-consistent standard errors of White (1980).

	Highest IVOL	Next 20%	Next 20%	Next 20%	Lowest IVOL	Highest –Lowest	All Stocks
Most overpriced (top 20%)	-2.25 (-11.91)	-1.32 (-8.72)	-0.80 (-5.79)	-0.79 (-5.31)	-0.45 (-3.92)	-1.80 (-8.28)	-0.81 (-8.14)
Next 20%	-0.92 (-5.76)	-0.40 (-3.00)	-0.21 (-2.08)	-0.27 (-2.83)	-0.08 (-0.82)	-0.84 (-4.33)	-0.23 (-3.88)
Next 20%	-0.13 (-0.88)	0.01 (0.11)	0.03 (0.25)	-0.21 (-2.15)	0.04 (0.48)	-0.18 (-0.95)	-0.07 (-1.47)
Next 20%	-0.07 (-0.42)	0.08 (0.69)	0.23 (2.54)	0.21 (2.69)	0.15 (1.93)	-0.23 (-1.10)	0.18 (4.45)
Most underpriced (bottom 20%)	0.68 (4.63)	0.66 (5.68)	0.41 (4.22)	0.31 (3.90)	0.10 (1.37)	0.57 (3.30)	0.28 (5.67)
Most overpriced – most underpriced	-2.93 (-12.31)	-1.98 (-9.81)	-1.21 (-6.53)	-1.10 (-6.08)	-0.55 (-3.69)	-2.38 (-9.08)	-1.09 (-8.05)
All stocks	-0.69 (-6.09)	-0.12 (-1.56)	-0.00 (-0.01)	0.05 (1.07)	0.08 (1.86)	-0.78 (-5.50)	

Table AVI
Average Log(Size) of Independently Double-Sorted Portfolios

The table reports the typical individual-stock average log(size) of the 25 independently double-sorted portfolios, first computing the median log(size) within each portfolio each month and then averaging across months. The 25 portfolios are formed by sorting stocks independently on the idiosyncratic volatility (IVOL) of their returns and mispricing, as determined by an average of the rankings produced by 11 anomaly variables. The idiosyncratic volatility is calculated as the volatility of the residuals $\epsilon_{i,t}$ in the regression,

$$R_{i,t} = a + bMKT_t + cSMB_t + dHML_t + \epsilon_{i,t},$$

where $R_{i,t}$ is the excess percent return in month t . The sample period is from 8/1965 to 1/2011.

	Highest IVOL	Next 20%	Next 20%	Next 20%	Lowest IVOL
Most overpriced	11.02	11.44	11.78	12.23	12.54
Next 20%	10.97	11.49	11.92	12.40	12.61
Next 20%	10.95	11.53	12.00	12.47	12.71
Next 20%	10.93	11.54	12.10	12.67	12.88
Most underpriced	10.91	11.54	12.09	12.66	12.98

Table AVII
Stock-Level Skewness for Independently Double-Sorted Portfolios

This table reports the typical stock-level skewness of daily returns for each of the 25 independently double-sorted portfolios, first computing the median stock-level skewness within each portfolio each month and then averaging across months. The 25 portfolios are formed by independently sorting stocks on idiosyncratic volatility (IVOL) and the mispricing measure. The mispricing measure is as an average of the ranking percentiles produced by 11 anomaly variables. The pre-formation skewness in Panel A is calculated for each stock using daily returns in the month prior to portfolio formation. The post-formation skewness in Panel B is calculated using daily returns in the month after portfolio formation. The sample period is from 8/1965 to 1/2011.

	Highest IVOL	Next 20%	Next 20%	Next 20%	Lowest IVOL
<u>Panel A: Pre-rank Firm-level Skewness</u>					
Most overpriced	0.4658	0.2658	0.1791	0.1169	0.0571
Next 20%	0.4727	0.2759	0.1946	0.1318	0.0709
Next 20%	0.4922	0.2917	0.1889	0.1332	0.0810
Next 20%	0.5148	0.3035	0.2105	0.1506	0.0957
Most underpriced	0.5525	0.3146	0.2199	0.1547	0.0946
<u>Panel B: Post-rank Firm-level Skewness</u>					
Most overpriced	0.2906	0.2624	0.2266	0.1717	0.1317
Next 20%	0.2840	0.2455	0.2138	0.1670	0.1445
Next 20%	0.2829	0.2375	0.2111	0.1749	0.1510
Next 20%	0.2820	0.2420	0.2113	0.1829	0.1674
Most underpriced	0.2699	0.2365	0.2078	0.1825	0.1755

Table AVIII
Pre-ranking Stock-Level Maximum Daily Return
for Independently Double-Sorted Portfolios

This table reports the typical stock-level maximum daily return in the pre-rank month for each of the 25 independently double-sorted portfolios, first computing the median stock-level maximum daily return within each portfolio each month and then averaging across months. The 25 portfolios are formed by independently sorting stocks on idiosyncratic volatility (IVOL) and the mispricing measure. The mispricing measure is as an average of the ranking percentiles produced by 11 anomaly variables. The pre-ranking maximum return is calculated using daily returns in the month prior to portfolio formation. The sample period is from 8/1965 to 1/2011.

	Highest IVOL	Next 20%	Next 20%	Next 20%	Lowest IVOL
Most overpriced	0.1031	0.0645	0.0477	0.0351	0.0225
Next 20%	0.1014	0.0640	0.0473	0.0352	0.0221
Next 20%	0.1014	0.0644	0.0474	0.0354	0.0222
Next 20%	0.1017	0.0645	0.0480	0.0357	0.0226
Most underpriced	0.1023	0.0649	0.0480	0.0356	0.0229

Table AIX
Average-Variance-Factor Betas of the Independently Double-Sorted Portfolios

The table reports the portfolio beta with respect to the average variance factor (ΔAV) for portfolios formed by sorting stocks independently on the idiosyncratic volatility (IVOL) of their returns and the mispricing measure, as determined by an average of the rankings produced by 11 anomaly variables. Also reported are results based on sorting by IVOL within the entire stock universe. In particular, following Chen and Petkova (2012), the portfolio beta is the coefficient f in the following regression,

$$R_{i,t} = a + bMKT_t + cSMB_t + dHML_t + e\Delta AC_t + f\Delta AV_t + \epsilon_{i,t},$$

where $R_{i,t}$ is the excess percent return in month t . ΔAC is the average correlation factor and ΔAV is the average variance factor, as defined in Chen and Petkova (2012). The sample period is from 8/1965 to 1/2011. All t-statistics (in parentheses) are based on the heteroskedasticity-consistent standard errors of White (1980). We report only the beta of the average-variance factor since this is the factor that Chen and Petkova (2012) conclude helps explain the IVOL effect.

	Highest IVOL	Next 20%	Next 20%	Next 20%	Lowest IVOL	Highest –Lowest
Most overpriced (top 20%)	0.97 (0.73)	1.28 (1.27)	1.86 (1.61)	0.06 (0.06)	0.39 (0.39)	0.58 (0.33)
Next 20%	1.33 (1.18)	0.87 (1.05)	-0.08 (-0.10)	0.62 (0.72)	-0.34 (-0.47)	1.68 (1.23)
Next 20%	1.72 (1.22)	1.38 (1.23)	-1.26 (-1.68)	-1.02 (-1.48)	-1.14 (-1.62)	2.86 (1.85)
Next 20%	2.77 (1.90)	1.67 (1.60)	0.58 (0.87)	-0.81 (-1.46)	-0.47 (-0.96)	3.23 (2.05)
Most underpriced (bottom 20%)	1.43 (1.20)	0.86 (0.96)	-0.62 (-0.91)	0.52 (0.84)	-0.61 (-0.96)	2.04 (1.35)
All stocks	1.74 (1.68)	1.39 (2.10)	0.22 (0.53)	-0.19 (-0.51)	-0.61 (-1.59)	2.35 (1.77)

Table AX
Cross-Sectional Regressions Using Volatility Factors

This table presents Fama-MacBeth regressions using 25 portfolios formed by sorting independently on idiosyncratic volatility (IVOL) and the mispricing measure constructed by averaging the ranking percentiles produced by 11 anomaly variables. We first run the following time-series regression within the full sample,

$$R_{i,t} = a + b_i MKT_t + c_i SMB_t + d_i HML_t + e_i \Delta AC_t + f_i \Delta AV_t + \epsilon_{i,t},$$

where $R_{i,t}$ is the excess percent return in month t , ΔAC is the average correlation factor, and ΔAV is the average variance factor, as defined in Chen and Petkova (2012). Then the following cross-sectional regression is run for each month t :

$$R_{i,t} = \gamma_0 + \gamma_{M,t} b_i + \gamma_{SMB,t} c_i + \gamma_{HML,t} d_i + \gamma_{\Delta AC,t} e_i + \gamma_{\Delta AV,t} f_i + \epsilon_{i,t}.$$

The sample period is from 8/1965 to 1/2011. The usual Fama-MacBeth estimates and t-statistics (in parentheses) are reported. The coefficients are multiplied by 100.

	coef	t-stat
γ_0	3.81	10.77
γ_M	-3.15	-7.94
γ_{SMB}	0.16	0.65
γ_{HML}	-0.62	-1.82
$\gamma_{\Delta AC}$	15.08	3.31
$\gamma_{\Delta AV}$	11.44	3.65