Internet Appendix: Horizon Pricing

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Internet Appendix

This appendix contains ancillary results for "Horizon Pricing."

I. Additional Tests

A. Illiquidity

Chordia, Subrahmanyam, and Tong (2014) find that the profitability of a number of asset-pricing anomalies has significantly declined for the subset of liquid stocks. Motivated by their results, we conduct an analysis of horizon pricing for two subsets of stocks sorted by their liquidity. In particular, we calculate the Amihud (2002) liquidity measure for each stock per year (using firms with at least 100 daily observations). "Liquid" ("illiquid") stocks are those with below (above) median Amihud measures in the previous year. We then estimate the cross-sectional regressions, as in Table 4, separately for each liquidity group. The regressors are standardized each period by their sample mean and cross-sectional standard deviation.

Table A1 presents the results. The main conclusion is that the β_{24}^{HML} and β_{3}^{LIQ} are not only priced among illiquid stocks. Therefore, these results are inconsistent with these estimated premia being a result of mispricing in the illiquid segment of the equity market.

B. Returns Across Various Holding Periods

Thus far, we estimate factor exposures over horizons ranging from one month to 61 months, while stocks are held for one month after portfolio formation when estimating risk premia. One might argue that the risk premia for long-horizon investors should be estimated using long-horizon returns for the dependent variable, either in portfolio sorts or Fama–MacBeth regressions. We argue that using short-horizon returns makes sense for several reasons. If a risk premium exists for a given factor using long-horizon betas, it will be present in short-horizon returns and available for both short-horizon and long-horizon investors. The main effect in returns is likely to be the risk premium, rather than the compounding effect of Levhari and Levy (1977). Using short-horizon returns to estimate the risk premium leads to more precise estimates of the risk premium due to the loss of degrees of freedom in using long-horizon returns. Additionally, using long-horizon returns to estimate the risk premium (using individual assets in the cross-sectional regressions) induces a survivorship bias into the risk premium estimates. For example, using 24-month returns to estimate the premium for 24-month beta risk will eliminate any asset that is delisted any time in the 24-month period after the ranking period. In essence, it is impossible to be a truly long-term buy-and-hold investor when assets disappear. The increased precision and reduced survivorship bias led us to choose to estimate risk premia using short-horizon returns for the bulk of our work.

However, as a check on the robustness of these results, we also estimate premia using two alternative methods of computing mean intermediate-horizon returns. The first method follows the Jegadeesh and Titman (1993) approach in calculating monthly returns of longer horizon buy-and-hold portfolios. Specifically, in each month t, we sort the stocks into ten value-weighted decile portfolios based on their previously estimated k-month factor beta, where k=1, 6, 12, 24 for MKT; k=1, 12, 24, 36 for HML; and k=1, 3, 6, 12 for LIQ. We form zero-cost, top-minus-bottom beta decile portfolios and hold them for h months, where

h ranges over all the values of k of each factor. In each month, we close out the positions initiated in month $t-h$. That is, under this trading strategy, each month, we revise the weights of $1/h$ of the securities in each zero-cost, factor/beta portfolio, and carry over the rest of the portfolios from the previous month. As in the previous analyses, betas are computed once a year (at year-end), and the most recent beta is used for portfolio formation.

Table A2, Panel A, shows that the factors MKT and HML continue to behave like intermediate-horizon risk factors, whereas LIQ continues to behave like a short-horizon risk factor. The average returns on portfolios sorted on the six-month MKT beta are significant at the 5% level for holding periods between 1 to 12 months. For the 12-month MKT beta, the returns are significant for a holding period of one month. For beta estimation periods of 24 and 36 months, five of the eight average returns on portfolios sorted on HML betas are significant at the 5% level, while the rest are significant at the 10% level. For LIQ beta portfolios sorted by three- and six-month horizon, seven of the eight average portfolios returns are significant at the 5% level (and the one remainder at the 10% level). The FF4 alphas on the LIQ portfolios are always significant at the 5% level at all holding periods when sorted on betas estimated over 1-, 3- and 6-month periods. Additionally, for every factor and for each value of k, we test for differences in estimated premia across different holding horizons h, and fail to reject they are equal. The driver of the horizon premia is therefore the estimation period k rather than the holding period h.

The results of the second method are reported in Panel B. We estimate cumulative buy-and-hold portfolio returns for each horizon h and annualize return spreads. Portfolios are formed each month, resulting in overlapping return series; standard errors are Newey-West adjusted using $h-1$ lags. The results are generally consistent with those reported in Panel A.

C. Incremental Betas

The analysis above investigates the pricing of the nine betas as distinct variables. In this section we examine the incremental contribution of estimating a beta over a longer horizon rather than over a shorter horizon. For example, rather than studying β_1^{HML}, β_{12}^{HML}, and β_{24}^{HML}, we examine β_1^{HML}, $\beta_{12}^{HML} - \beta_1^{HML}$, and $\beta_{24}^{HML} - \beta_{12}^{HML}$.

Table A3 reports the results using the Fama–MacBeth (1973) cross-sectional analysis in which characteristics are also included as explanatory variables, similar to Table 4. Panel A repeats the cross-sectional analysis of the betas in Columns 11, 12, and 13 of Table 4, but because our objective here is to test the significance of differences in betas, the units in Table A3 are not standardized. Panel B reports the results for the differences in betas. Consistent with the results in Table 4, the contribution of the one-month market beta and the contributions of $\beta_6^{MKT} - \beta_1^{MKT}$, and $\beta_{12}^{MKT} - \beta_6^{MKT}$ are insignificant. In contrast, the contribution of $\beta_{12}^{HML} - \beta_1^{HML}$ is significant at the 10% level and that of $\beta_{24}^{HML} - \beta_{12}^{HML}$ is significantly positive at 5%. Lastly, while β_3^{LIQ} is significantly positively priced at 10% in Panel A, Panel B shows that the incremental contributions of $\beta_3^{LIQ} - \beta_1^{LIQ}$ and $\beta_6^{LIQ} - \beta_3^{LIQ}$ are not significant. Thus, the changes in HML betas from a one-month to a one-year horizon and from a one-year to a two-year horizon have significant explanatory power for the cross section of returns, consistent with our prior results. Additionally, liquidity risk is priced at short horizons, but the changes in betas at longer horizons have no explanatory power for returns.

References

Amihud, Y. "Illiquidity and Stock Returns: Cross-section and Time-series Effects." *Journal of Financial Markets,* **5** (2002), 31–56.

Chordia, T.; A. Subrahmanyam; and Q. Tong. "Have Capital Market Anomalies Attenuated in the Recent Era of High Liquidity and Trading Activity?" *Journal of Accounting and Economics,* **58** (2014), 41-58.

Jegadeesh, N., and S. Titman. "Returns to Buying Winners and Selling Losers: Implications for Stock Market Efficiency." *Journal of Finance,* **48**, (1993), 65–91.

Levhari, D., and H. Levy. "The Capital Asset Pricing Model and the Investment Horizon." *Review of Economic Studies,* **59** (1977), 92–104.

Table A1: Stock Illiquidity

The Amihud (2002) measure of stock i in year y, $ILLIQ_{i,y}$, is the average daily ratio of absolute return to the dollar trading volume, averaged over all the trading days in the year where the daily ratio is defined. We require at least 100 valid daily ratios for a stock to be included in the sample. In each month in year y from 1965 to 2013, we estimate value-weighted monthly Fama–MacBeth regressions for groups separated by the Amihud measure in year y-1. Those with an Amihud measure above the median are illiquid stocks, and those below the median are liquid stocks. We exclude penny stocks from our sample. We standardize each independent variable in the entire cross section to a mean of zero and a standard deviation of one. Reported are the time-series averages and T-statistics (in brackets) of cross-sectional regression coefficients, weighted by the inverse of the standard errors of monthly coefficients. Penny stocks are excluded and the sample period is from 1965 to 2013.

	Panel A: Liquid Stocks			Panel B: Illiquid Stocks		
	(1)	(2)	(3)	(1)	(2)	(3)
β_{12}^{MKT}	0.04			0.02		
	[0.89]			[0.73]		
β_{24}^{HML}		0.13			0.07	
		[2.79]			[2.06]	
β_{3}^{LIQ}			0.09			0.05
			[2.14]			[2.06]
Size	-0.10	-0.11	-0.10	-0.06	-0.09	-0.05
	[-1.76]	[-1.91]	[-1.74]	[-0.64]	[-0.95]	[-0.52]
B/M	0.12	0.07	0.10	0.18	0.17	0.18
	[1.76]	[1.09]	[1.57]	[5.07]	[4.92]	[5.16]
$r_{11,-2}$	0.36	0.31	0.33	0.19	0.16	0.19
	[3.59]	[3.17]	[3.37]	[3.81]	[3.15]	[3.80]
Intercept	1.07	1.11	1.07	0.85	0.90	0.85
	[4.63]	[4.69]	[4.66]	[4.09]	[4.32]	[4.12]
Adjusted R^2	0.09	0.09	0.09	0.04	0.03	0.03

Table A2: Varying Holding Period

This table reports results on estimating risk premia using two methods of computing mean intermediate-horizon returns. The first method presented in Panel A follows the Jegadeesh and Titman (1993) approach in calculating monthly returns of longer horizon buy-and-hold portfolios. Specifically, in each month t, we sort the stocks into ten value-weighted decile portfolios based on their previously estimated k-month factor beta, where k=1, 6, 12, 24 for MKT; k=1, 12, 24, 36 for HML; and k=1, 3, 6, 12 for LIQ. To increase power, we also use the portfolios corresponding to the adjacent horizons for horizons greater than one month. For example, to calculate the portfolio return spread of a one-year horizon beta, we use the portfolio returns of 11-, 12-, and 13-month horizons. That is, we average the returns of the three portfolios per month to create a time series of monthly excess returns. We form zero-cost, top-minus-bottom beta decile portfolios and hold them for h months, where h ranges over all the values of k of each factor. In each month, we close out the positions initiated in month t-h. That is, under this trading strategy, each month, we revise the weights of $1/h$ of the securities in each zero-cost, factor/beta portfolio, and carry over the rest of the portfolios from the previous month. Betas are computed once a year (at the previous year-end), and the most recent beta is used for portfolio formation. Reported are the average annualized percentage return spread (with T-statistic in brackets) between the top beta decile and the bottom beta decile for each beta, k and h combination. In Panel B, we estimate cumulative buy-and-hold portfolio returns for each horizon h and annualized return spreads. Portfolios are formed each month, resulting in overlapping return series; standard errors are Newey-West adjusted using h-1 lags. Penny stocks measured at the beginning of each portfolio ranking month are excluded. The sample period is 1965 through 2013.

	β_k^{MKT} Return Spread					β_k^{HML} Return Spread					β_k^{LIQ} Return Spread				β_k^{LIQ} Alpha Spread			
Panel A: Jegadeesh-Titman (1993) Approach (Annualized Return Spread)																		
h	k=1	6	12	24		k=1	12	24	36		k=1	3	6	12	k=1	3	6	12
1	0.41	5.68	4.08	1.03	1	2.01	3.56	4.78	4.72	1	2.89	3.84	4.04	0.25	4.82	4.44	4.34	0.84
	[0.16]	[2.75]	[2.13]	[0.55]		[0.67]	[1.64]	[2.27]	[2.39]		[1.46]	[2.10]	[2.24]	[0.16]	[2.36]	[2.35]	[2.35]	[0.51]
6	-0.42	4.37	2.42	-0.17	12	1.92	3.41	4.14	3.25	3	2.64	3.61	4.00	0.70	4.37	3.94	4.14	1.05
	[-0.17]	[2.22]	[1.38]	[-0.10]		[0.72]	[1.70]	[2.13]	[1.78]		[1.35]	[2.00]	[2.24]	[0.44]	[2.16]	[2.12]	[2.25]	[0.64]
12	-0.02	3.95	2.09	-0.33	24	2.24	2.65	3.27	3.31	6	2.89	3.54	3.81	1.14	4.56	3.78	3.92	1.29
	[-0.01]	[2.07]	[1.25]	[-0.19]		[0.89]	[1.46]	[1.87]	[2.01]		[1.49]	[2.02]	[2.16]	[0.73]	[2.28]	[2.09]	[2.16]	[0.80]
24	1.11	3.08	1.10	0.03	36	1.29	2.06	2.98	3.48	12	2.91	3.28	3.66	1.44	4.40	3.50	3.75	1.23
	[0.50]	[1.71]	[0.69]	[0.02]		[0.54]	[1.26]	[1.88]	[2.27]		[1.54]	[1.94]	[2.13]	[0.94]	[2.25]	[2.00]	[2.11]	[0.78]
Panel B: Overlapping Cumulative Return (Annualized Return Spread)																		
h	k= 1	6	12	24		k=1	12	24	36		k=1	3	6	12	k=1	3	6	12
1	0.41	5.68	4.08	1.03	1	2.01	3.56	4.78	4.72	1	2.89	3.84	4.04	0.25	4.82	4.44	4.34	0.84
	[0.16]	[2.75]	[2.13]	[0.55]		[0.67]	[1.64]	[2.27]	[2.39]		[1.46]	[2.10]	[2.24]	[0.16]	[2.32]	[2.35]	[2.36]	[0.49]
6	-0.68	4.64	2.63	-0.54	12	1.25	3.35	4.43	3.59	3	2.67	3.80	3.98	0.61	2.36	4.65	3.39	0.71
	[-0.30]	[2.54]	[1.57]	[-0.29]		[0.43]	[1.49]	[1.97]	[1.81]		[1.62]	[2.50]	[2.63]	[0.40]	[1.27]	[2.77]	[2.17]	[0.40]
12	-1.04	4.23	1.78	-1.20	24	1.53	2.65	3.40	4.13	6	3.25	3.83	4.05	1.16	2.96	5.29	4.59	2.33
	[-0.45]	[2.09]	[1.12]	[-0.61]		[0.55]	[1.24]	[1.29]	[1.82]		[1.90]	[2.46]	[2.61]	[0.74]	[1.80]	[3.10]	[2.46]	[1.31]
24	0.22	3.25	0.16	-1.33	36	0.37	2.23	3.69	4.75	12	3.43	3.59	4.11	1.74	2.03	1.83	1.87	-0.27
	[0.09]	[1.50]	[0.09]	[-0.65]		[0.12]	[0.94]	[1.41]	[1.89]		[1.77]	[1.95]	[2.32]	[1.02]	[1.22]	[0.84]	[0.96]	[-0.15]

Table A3: Fama–MacBeth Regression Results—Incremental Beta

The table reports the results of Fama–MacBeth regressions using nonstandardized independent variables. In each month t, we perform value-weighted least square cross-sectional regressions, where the weight is firm market capitalization at the previous month-end. For all betas in the regression of month t, the average beta of the decile portfolio that a firm is assigned to based on that beta is used for the firm beta. Independent variables are not standardized. β_1^{MKT} is the market beta estimated using monthly returns in the years $[y-5, y-1]$ for each month t in year y. β_6^{MKT} is the market beta estimated using overlapping six-month cumulative returns. $\beta_6^{MKT} - \beta_1^{MKT}$ is the difference between β_6^{MKT} and β_1^{MKT}. Reported are the time-series averages and T-statistics (in brackets) of cross-sectional coefficients, weighted by the inverse of the standard errors of monthly coefficients. Penny stocks are excluded and the sample period is from 1965 to 2013.

Panel A: Betas (Nonstandardized)			
	(1)	(2)	(3)
β_1^{MKT}	-0.13		
	[-1.56]		
β_6^{MKT}	0.00		
	[0.05]		
β_{12}^{MKT}	0.04		
	[1.05]		
β_1^{HML}		0.02	
		[0.38]	
β_{12}^{HML}		-0.02	
		[-0.91]	
β_{24}^{HML}		0.06	
		[2.92]	
β_1^{LIQ}			[0.09]
			[0.85]
β_3^{LIQ}			[0.15]
			[1.84]
β_6^{LIQ}			[-0.05]
			[-0.98]
Size	-0.06	-0.06	-0.05
	[-2.31]	[-2.35]	[-1.93]
B/M	0.18	0.10	0.16
	[2.24]	[1.41]	[1.90]
$r_{11,-2}$	0.67	0.51	0.54
	[4.01]	[3.22]	[3.29]
Intercept	1.17	1.24	1.07
	[4.21]	[3.66]	[3.19]
Adjusted R^2	0.10	0.10	0.09

Panel B: Differences in Betas			
	(1)	(2)	(3)
β_1^{MKT}	-0.06		
	[-0.60]		
$\beta_6^{MKT} - \beta_1^{MKT}$	0.06		
	[1.34]		
$\beta_{12}^{MKT} - \beta_6^{MKT}$	0.04		
	[1.05]		
β_1^{HML}		0.07	
		[1.05]	
$\beta_{12}^{HML} - \beta_1^{HML}$		0.04	
		[1.78]	
$\beta_{24}^{HML} - \beta_{12}^{HML}$		0.06	
		[2.92]	
β_1^{LIQ}			0.21
			[2.12]
$\beta_3^{LIQ} - \beta_1^{LIQ}$			0.11
			[1.32]
$\beta_6^{LIQ} - \beta_3^{LIQ}$			-0.05
			[-0.98]
Size	-0.06	-0.06	-0.05
	[-2.31]	[-2.35]	[-1.93]
B/M	0.18	0.10	0.16
	[2.24]	[1.41]	[1.90]
$r_{11,-2}$	0.67	0.51	0.54
	[4.01]	[3.22]	[3.29]
Intercept	1.17	1.24	1.07
	[4.21]	[3.66]	[3.19]
Adjusted R^2	0.099	0.102	0.090