

# **Internet Appendix for**

## **“On the High Frequency Dynamics of Hedge Fund Risk Exposures<sup>\*</sup>”**

This internet appendix provides supplemental analyses to the main tables in “On the High Frequency Dynamics of Hedge Fund Risk Exposures”

The first section describes the process used to create the consolidated database of hedge funds that is employed in this paper from the TASS, HFR, MSCI and CISDM databases. Prior to Table IA.IV, we describe the simulation, and prior to Table IA.V, we describe the robustness checks conducted in that table. The tables and figures are as follows:

Table IA.I: Summary Statistics on Funds in Consolidated Database

Table IA.II: Static Factor Models for Daily and Monthly Hedge Fund Style Indexes

Table IA.III: Linear Model for Daily and Monthly Hedge Fund Style Indexes

Table IA.IV: Comparison of results based on simple and log returns

Table IA.V: Results from a simulation study of the estimation method

Table IA.VI: Robustness checks

Figure IA.1: Static factors selected by strategy

Figure IA.2: Some possible shapes with exponential-Almon weight functions

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## **The Consolidated Hedge Fund Database**

As hedge funds can report to one or more databases, the use of any single source will fail to capture the complete universe of hedge fund data. We therefore aggregate data from TASS, HFR, CISDM, BarclayHedge and Morningstar, which together have 48,508 records that comprise administrative information as well as returns and AUM data for hedge funds, fund of funds and CTAs. However this number hides the fact that there is significant duplication of information, as multiple providers often cover the same fund. To identify all unique entities, we must therefore consolidate the aggregated data.

To do so, we adopt the following steps:

1. **Group the Data:** Records are grouped based on reported management company names. To do so, we first create a 'Fund name key' and a 'Management company key' for each data record, by parsing the original fund name and management company name for punctuations, filler words (e.g., 'Fund', 'Class'), and spelling errors. We then combine the fund and management name keys into 4,409 management company groups.
2. **De-Duplication:** Within a management company group, records are compared based on returns data (converted into US dollars), and 18,130 match sets are created out of matching records, allowing for a small error tolerance limit (10% deviation) to allow for data reporting errors.
3. **Selection:** Once all matches within all management company groups are identified, a single record representing the unique underlying fund is created for each match set. We pick the record with the longest returns data history available is selected from the match set, and fill in any missing administrative information using the remaining records in the match set. The process thus yields 18,130 representative fund records.

Finally, we apply the criterion that 24 contiguous months of return data are available for each of the funds in the sample we use in the paper. This brings the final number of funds in the sample to 14,194. Table IA.I below shows the number of these final funds from each of the five sources (HFR, TASS, CISDM, MSCI and BarclayHedge), and the number of these funds that are alive and defunct (either liquidated or closed).

**Table IA.I**  
**Data Sources**

This table shows the number of funds from each of the five sources (HFR, TASS, CISDM, MSCI and BarclayHedge), and the number of these funds that are alive and defunct (either liquidated or closed) in the consolidated universe of hedge fund data.

Source Dataset	Number of Funds	Alive	Defunct	% Defunct
TASS	5962	2738	3224	54.076
HFR	3712	2449	1263	34.025
CISDM	2782	860	1922	69.087
BarclayHedge	966	930	36	3.727
Morningstar	772	681	91	11.788
Total	14194	7658	6536	46.048

**Table IA.II**  
**Static Factor Models for Daily and Monthly Hedge Fund Style Indexes**

This table shows results from a simple two-factor model applied to five hedge fund style index returns, identified in the first row of the table. In all cases a constant is included, and two factors from the set of four daily Fung-Hsieh factors are selected using the Bayesian Information Criterion. The first row presents annualized alpha. Robust t-statistics are reported below the parameter estimates, and the R2 and adjusted R2 are reported in the bottom two rows of the table.

	Equity Hedge		Macro		Directional		Merger Arbitrage		Relative Value	
	Daily	Monthly	Daily	Monthly	Daily	Monthly	Daily	Monthly	Daily	Monthly
Alpha	1.575	1.595	3.738	3.322	3.044	3.709	5.444	5.331	-1.032	-0.473
t-stat	0.781	0.880	0.985	0.985	0.995	1.453	3.376	4.208	-0.422	-0.234
SP500	0.259	0.321			0.270	0.327	0.111	0.063	0.063	0.190
t-stat	15.395	6.070			11.298	4.029	5.181	2.332	1.811	3.935
SMB			0.070	0.111						
t-stat			2.111	0.849						
TCM10Y			-0.905	-0.376						
t-stat			-2.742	-0.405						
BAAMTSY	-2.006	-2.027			-2.720	-3.861	-0.460	-0.579	-2.544	-6.080
t-stat	-4.184	-2.728			-3.847	-3.686	-0.804	-1.935	-3.724	-9.584
R2	0.549	0.681	0.014	0.007	0.454	0.664	0.290	0.182	0.090	0.784
R2adj	0.548	0.672	0.013	-0.021	0.453	0.652	0.289	0.160	0.089	0.778

**Table IA.III**  
**The Linear Model for Daily and Monthly Hedge Fund Style Indexes**

This table corresponds to Table II of the paper, but contains results for four other hedge fund indexes. It shows results from a two-factor model applied to four hedge fund style index returns, identified in the first row of the table, allowing for time variation in the factor exposures as a linear function of conditioning variables (i.e.,  $g(Z)$  is linear in  $Z$ , as in equation 7 of the paper). Two factors from the set of four daily Fung-Hsieh factors are selected for each style, using the Bayesian Information Criterion. The first row presents annualized alpha. Robust standard errors are reported below the parameter estimates, and the  $R^2$  and adjusted  $R^2$  are also reported. The fourth-last row presents the p-value for the joint significance of the coefficients on the interaction terms (Gamma1, Gamma2, Delta1, Delta2). The second-last and final rows present the correlation between the time series of daily factor exposures estimated using daily and monthly data, for each of the two factors. For ease of comparison,  $Z$  is picked to be dLevel for all indexes.

	Convertible Arb		Distressed		Market Neutral		Event Driven	
	Daily	Monthly	Daily	Monthly	Daily	Monthly	Daily	Monthly
alpha	-4.736	5.316	-1.197	5.330	-0.545	0.743	3.663	5.231
s.e.	-1.025	1.384	-0.558	2.243	-0.328	0.465	1.685	3.129
beta1	-0.062	0.052	-0.062	0.076	-0.009	-0.006	0.224	0.277
s.e.	-3.715	0.549	-8.174	1.440	-1.562	-0.170	28.559	6.695
beta2	-3.434	-7.546	-0.024	-0.032	-0.014	-0.057	-1.870	-2.229
s.e.	-5.665	-5.778	-1.544	-0.379	-1.149	-1.014	-6.560	-3.922
gam1	0.000	-0.023	-0.001	-0.026	0.002	0.004	0.006	0.010
s.e.	0.270	-2.021	-1.037	-3.756	4.387	0.798	7.864	1.985
gam2	0.163	-0.084	0.012	0.039	0.004	-0.002	-0.009	0.163
s.e.	2.486	-0.399	6.107	2.354	2.712	-0.218	-0.284	1.772
delta1	0.043	0.147	0.009	0.070	-0.003	0.016	-0.001	0.027
s.e.	8.688	6.514	3.655	4.942	-1.795	1.703	-0.284	2.747
delta2	1.423	3.698	0.004	0.100	-0.004	0.029	0.215	-1.143
s.e.	9.454	2.591	0.809	2.545	-1.221	1.092	3.039	-1.839
R2	0.150	0.820	0.086	0.673	0.032	0.083	0.432	0.754
R2adj	0.147	0.804	0.083	0.644	0.029	0.003	0.430	0.733
pval	0.000	0.000	0.000	0.000	0.000	0.327	0.000	0.000
Corr-b1		0.854		0.792		0.309		0.781
Corr-b2		0.902		0.867		-0.492		-0.946

**Table IA.IV**  
**Comparison of results based on simple and log returns**

This table reports the results from the estimation of the linear model for hedge fund risk exposures, described in Section 2.2.1, and can be compared with the results presented in Table II of the paper. The columns labeled “True” are based on daily simple returns that are compounded to compute monthly simple returns. The columns labeled “Approx” use simple returns but ignore compounding when computing monthly returns. The columns labeled “Log” are based on log returns, which cumulated to monthly returns exactly, but render the factor model only approximate.

	Equity Hedge			Macro			Directional			Merger Arbitrage			Relative Value		
	True	Approx	Log	True	Approx	Log	True	Approx	Log	True	Approx	Log	True	Approx	Log
alpha	3.127	3.187	3.064	3.586	3.452	3.200	7.702	7.778	7.612	4.494	4.462	4.450	3.891	4.006	3.980
s.e.	2.058	2.051	2.053	3.864	3.839	3.859	3.230	3.206	3.213	1.404	1.396	1.402	1.817	1.818	1.820
beta1	0.328	0.326	0.327	0.125	0.123	0.121	0.250	0.248	0.248	0.104	0.104	0.104	0.076	0.076	0.076
s.e.	0.051	0.051	0.051	0.145	0.144	0.144	0.082	0.081	0.081	0.035	0.034	0.035	0.045	0.045	0.045
beta2	-1.732	-1.761	-1.802	-0.829	-0.810	-0.766	-3.202	-3.239	-3.293	-0.617	-0.592	-0.614	-5.718	-5.750	-5.795
s.e.	0.698	0.695	0.698	1.255	1.247	1.248	1.040	1.032	1.037	0.476	0.473	0.477	0.616	0.616	0.619
gam1	0.010	0.010	0.010	0.001	0.002	0.003	0.003	0.002	0.002	0.009	0.009	0.009	-0.010	-0.010	-0.010
s.e.	0.006	0.006	0.006	0.025	0.025	0.025	0.009	0.009	0.009	0.004	0.004	0.004	0.005	0.005	0.005
gam2	0.027	0.023	0.027	0.075	0.071	0.069	-0.025	-0.028	-0.025	0.028	0.029	0.027	-0.014	-0.004	0.002
s.e.	0.113	0.112	0.113	0.150	0.149	0.148	0.170	0.169	0.170	0.077	0.076	0.077	0.100	0.100	0.100
delta1	0.031	0.033	0.034	-0.024	-0.024	-0.022	0.051	0.054	0.054	-0.003	-0.004	-0.003	0.047	0.050	0.050
s.e.	0.012	0.012	0.012	0.073	0.073	0.071	0.018	0.018	0.018	0.008	0.008	0.008	0.011	0.011	0.011
delta2	0.200	0.280	0.325	1.128	1.103	1.082	0.877	1.040	1.119	0.200	0.128	0.187	-0.084	0.007	0.099
s.e.	0.791	0.788	0.763	0.776	0.771	0.763	1.176	1.167	1.130	0.539	0.536	0.521	0.698	0.698	0.676
R2	0.723	0.730	0.734	0.049	0.049	0.049	0.696	0.710	0.715	0.262	0.250	0.262	0.834	0.843	0.846
R2adj	0.699	0.706	0.710	-0.034	-0.035	-0.035	0.661	0.677	0.683	0.197	0.183	0.197	0.820	0.829	0.832
pval	0.012	0.010	0.008	0.551	0.558	0.557	0.068	0.043	0.035	0.146	0.122	0.150	0.000	0.000	0.000

**Table IA.V**  
**Results from a simulation study of the estimation method**

This table reports the mean and standard deviation, across 1000 independent simulation replications, of estimates of the parameters of a model of time-varying factor exposures. The results for ten different simulation designs are presented. Simulation design parameters are presented in the first panel of the table, and the mean and standard deviation of the simulation distribution of parameter estimates are presented in the second and third panels. The true values of the four parameters are presented in the first column of the table. The values for alpha, gamma and delta are scaled up by a factor of 100 for ease of interpretability.

		1	2	3	4	5	6	7	8	9	10	
		True values	Base scenario	Short sample	Long sample	Low autocorr in Z	High autocorr in Z	Corr b/w F, Z	Neg autocorr in F, rhoFZ=0	Pos autocorr in F, rhoFZ=0	Neg autocorr in F, rhoFZ=0.5	Pos autocorr in F, rhoFZ=0.5
	T		60	24	120	60	60	60	60	60	60	60
	rhoFZ		0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.5	0.5
	phiZ		0.5	0.5	0.5	0.0	0.9	0.5	0.5	0.5	0.5	0.5
	phiF		0.0	0.0	0.0	0.0	0.0	0.0	-0.2	0.2	-0.2	0.2
Mean	Alpha*100	0.758	0.715	0.827	0.794	0.729	0.773	0.812	0.780	0.735	0.725	0.721
Mean	Beta	0.400	0.400	0.397	0.399	0.400	0.401	0.400	0.401	0.400	0.399	0.401
Mean	Gamma*100	0.200	0.198	0.198	0.200	0.198	0.200	0.200	0.199	0.201	0.198	0.199
Mean	Delta*100	-0.400	-0.391	-0.400	-0.409	-0.399	-0.404	-0.410	-0.381	-0.392	-0.397	-0.394
St dev	Alpha*100		0.089	0.146	0.062	0.089	0.092	0.194	0.085	0.091	0.191	0.191
St dev	Beta		0.035	0.060	0.024	0.033	0.035	0.035	0.042	0.031	0.041	0.029
St dev	Gamma*100		0.005	0.009	0.003	0.008	0.003	0.005	0.006	0.004	0.005	0.004
St dev	Delta*100		0.038	0.062	0.026	0.035	0.052	0.034	0.039	0.034	0.037	0.031

## Robustness Checks

Table IA.V presents robustness checks used to identify whether the method proposed in this paper performs well over different sample periods, over different samples of funds, and under different transformations of hedge fund returns. In all these robustness checks, we consider the linear model for  $g(Z)$ , and use  $dLevel$  as  $Z$ . We consider a model using both daily and monthly conditioning information, as well as a model based only on monthly information.

The first robustness check that we run is to split the sample period into two halves, with the second half beginning in 2002, after the NASDAQ crash, and extending up to 2009, including the credit crisis period. We find that our method performs relatively less well in the early period, with 14.2% of funds rejecting the null of no significant interaction variables. In the second sub-period, we find almost 30% of the funds selecting interactions. This might be explained by the population of funds shifting towards funds with faster-moving trading strategies, which would suggest that our method is more appropriate to use in the contemporary setting. The model using only monthly information performs equally well in both sub-periods.

Next, we investigate our use of the Getmansky, Lo and Makarov (2004) unsmoothing of hedge fund returns. Our baseline results us 2 lags when implementing this model, and we find that our results are essentially unaffected by the choice of using more lags (4) or no lags.

We then condition on the length of available return history for the funds, and find that the both models perform better for funds with longer return histories, which is understandable given that it gives us more information with which to pick up changes in risk exposures.

Finally, we condition on the size of the fund. We find that both methods work better for larger hedge funds (measured by the average AUM over the fund's lifetime), and worse for funds in the smallest tercile of AUM.



**Table IA.VI**  
**Robustness Checks**

This table presents the proportion of funds with significant time variation based on our linear model ( $g(Z)$  linear in  $Z$ , allowing for both daily and monthly variation in  $Z$ ; or only monthly variation in  $Z$ ), using dLevel as  $Z$ . These proportions selected change when the specification is altered according to the robustness checks itemized in the rows of the first column. The first row is taken from the main table of linear model results (Table III) and is repeated here for ease of reference. The first set of robustness checks splits the sample period into two halves; the second set alters the type of “unsmoothing” done to the returns prior to testing; the third set sorts funds according to their history lengths in the consolidated database; and the fourth set sorts funds according to their average assets under management.

Robustness Test	N(Funds)	Daily and Monthly	Only Monthly
Main Results in Paper	14194	25.673	15.393
<u>Sample Period</u>			
Earlier period (1994:01-2001:12)	5106	14.219	14.044
Later period (2002:01-2009:06)	11386	29.832	15.168
<u>Smoothing</u>			
Raw returns (no GLM)	14194	24.600	13.800
Longer (4) MA lags in GLM model	14194	24.700	16.300
<u>Fund History Length</u>			
$24 \leq N(\text{Fund Observations}) < 36$	2697	13.200	7.379
$36 \leq N(\text{Fund Observations}) < 60$	4394	20.096	11.174
$N(\text{Fund Observations}) \geq 60$	7103	31.635	20.301
<u>Fund Size</u>			
Avg AUM $\leq$ 33rd Prctile	3963	15.821	11.380
33rd Prctile $<$ Avg AUM $\leq$ 66th Prctile	4085	24.357	16.010
Avg AUM $>$ 66th Prctile	3963	32.677	18.193

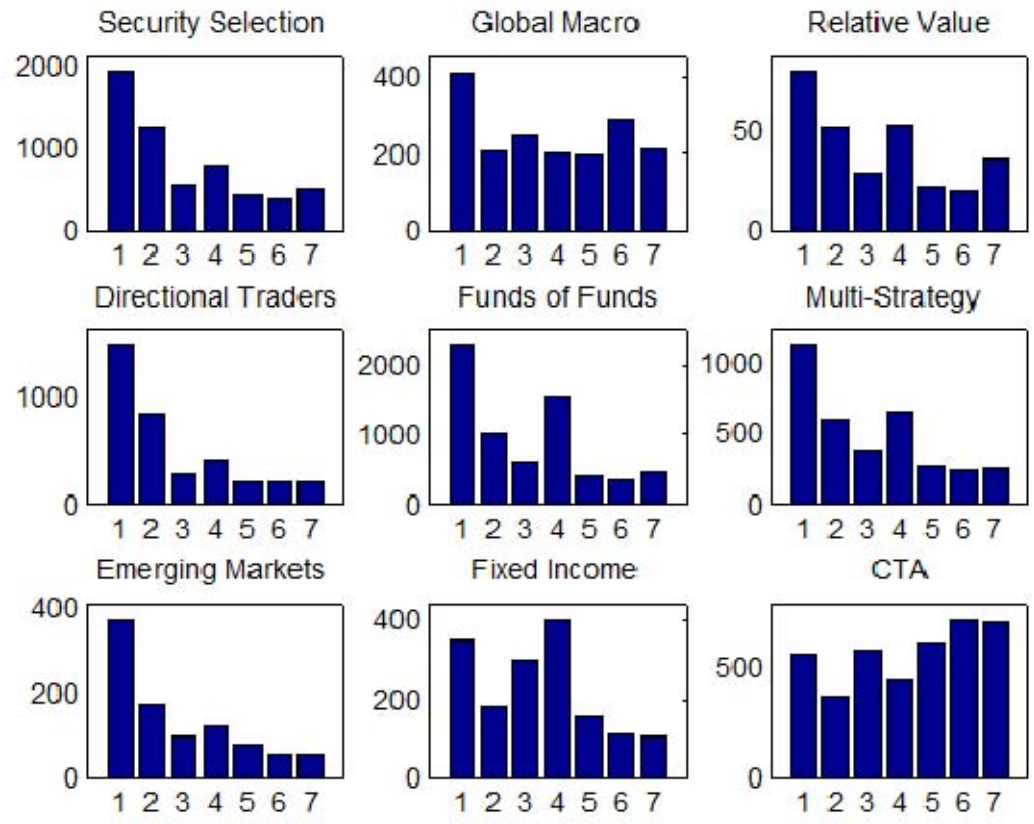


Figure IA.1: Static factors selected by strategy

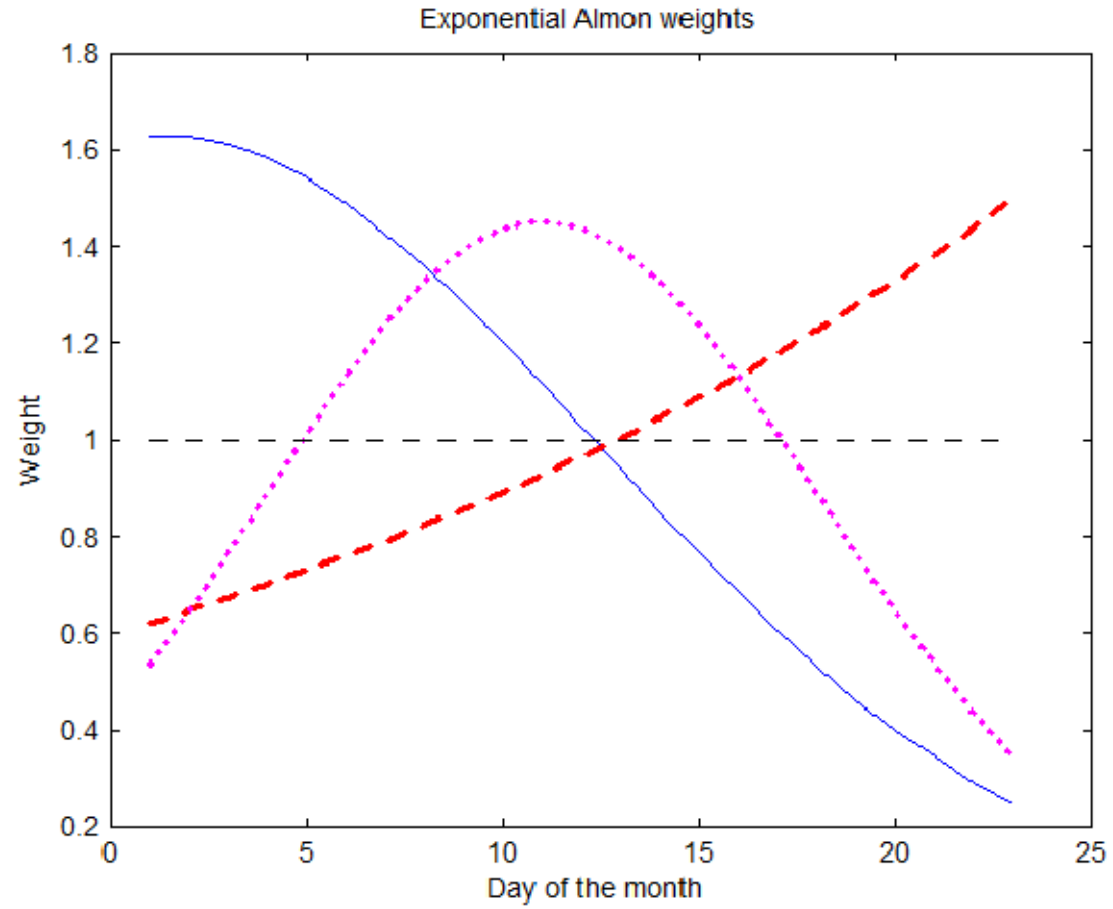


Figure IA.2: Some possible shapes with exponential-Almon weight functions