Online Appendix for "Prime Broker-Level Comovement in Hedge Fund Returns: Information or Contagion?"

This Online Appendix contains sections and results removed from the main paper during the review process in response to a comment that the paper is too long.

A The PB-Level Comovement in Hedge Fund Returns: Additional Tests

In this section, we report some additional robustness checks of our main results presented in Table 2. First, we consider including the PB distress variables examined by Klaus and Rzepkowski (2009) in the initial filtering regressions. Next, we conduct the analysis on style subsamples to see whether our results are confined to a particular style of hedge funds. We then analyze whether our results change when we drop the PB information matched for the period before the first download date. Further, we consider using value-weighted PB, style, and market indices. Finally, we examine whether our results are driven by possible imperfections in our style control.

A.1 PB Distress Variables

Klaus and Rzepkowski (2009) show that hedge fund returns load significantly on the changes in CDS spread and distance-to-default of the PB associated with the corresponding fund. To see whether these PB distress variables, as PB-specific components in hedge fund returns, give rise to the comovement that we document, we add these and other PB distress variables considered by Klaus and Rzepkowski (2009) in the initial filtering regressions and rerun the analysis using the filtered returns obtained that way. PB distress variables included in the filtering regressions are: Change in the 5-year CDS spread, change in (the negative of) the distance-to-default, and change in the option-implied volatility, as well as the one-month lagged terms of these variables (in addition to the Fung and Hsieh (2004) seven factors).[1] The results are reported in the first two rows of Panels A and B of Table OA.1 and are not substantially different from the results reported in Table 2.

A.2 Style Subsamples

Using a sample of merger arbitrage hedge funds, Goldie (2011) finds that funds profitably concentrate their investments in merger deals where their PBs act as advisors. While this finding exemplifies how PBs could play an information-provision role for their hedge fund clients and may imply the existence of PB-level comovement among merger arbitrageurs, we do not expect that our full-sample results are due entirely to this particular style of funds. To check this, we conduct subsample analyses similar to those in Table 8, but based on styles. The results are summarized in Table OA.2 and show that PB-level comovement does indeed arise for event-driven style (to which merger arbitrage funds belong), but it is by no means confined to this style category only: At least five styles out of nine (emerging markets, event driven, long/short equity, managed futures, and multi-strategy) robustly exhibit the comovement, with emerging markets and long/short equity styles clearly standing out in terms of magnitude.[2] Importantly, the fact that long/short equity funds exhibit the strongest PB-level comovement alleviates concerns of any PB-specific valuation mechanisms (for calculating the fund's NAV) driving our results, because these funds hold mostly liquid, equity securities, which are traded and priced on exchanges (Jorion and Schwarz 2014).[3]

[1] As Klaus and Rzepkowski (2009) also note, much of the data required to compute these variables is unavailable before 2004. In an unreported work, we also add PB stock returns and the results are similar.

[2] These five styles represent over 80% of all sample funds. We exclude dedicated short bias and options strategy due to an insufficient number of funds.

[3] Meanwhile, emerging markets funds showing strong PB-level comovement echoes our earlier result on the offshore versus onshore subsamples (see Table 8) because emerging markets style is dominated mostly by offshore funds unlike other style categories in TASS (Aragon, Liang, and Park 2014).

A.3 Observations Before the First Download Date

Although funds do not change PBs often (see Section 2), using the PB information contained in the March 2007 download (or a later download in which the fund first appears) to match with all return observations before the download date may create noise in the data. To check the impact of this noise, we repeat the analysis after discarding the PB information matched with return observations that precede the download date (or the last reporting date, if the fund is already "dead" in the first download containing it) (1) by more than 36 months (as in Chung and Teo 2012) or (2) at all (as in Aragon and Strahan 2012). Note that the latter may be too conservative a choice because it means that we discard the PB information of all graveyard funds that cease reporting to TASS before the first download date, although the information in the months leading up to the cessation can be accurate; similarly, it means that we also do not assign the PB information to all live funds for the period before the first download date, although PB information in the months leading up to the download date can be accurate. As a result, we drop 154,226 (76.5%) of the observations by the latter choice, and 71,418 (35.4%) by the former. The results are presented in the third to sixth rows of each panel of Table OA.1 and are similar to, if not stronger than, those reported in Table 2.

A.4 Value-Weighted Indices

Following Pirinsky and Wang (2006), we use equal weighting when computing the PB index and other independent variables in Equation (1). This is because equal weighting can better address the question of how a fund comoves with others sharing the same PB, as it does not emphasize or deemphasize the fund's comovement with other funds based on the size of the latter as long as they share a PB with the fund. In addition, the frequent occurrence of discontinuities in the historical series of AUM, as noted by Fung and Hsieh (2004), means that value-weighted indices discard funds that do not report AUM in the previous month (on average, about 25% of the funds included in the equally-weighted PB index are excluded from the value-weighted PB index, for this reason). Nevertheless, the results obtained using value-weighted indices, reported in the seventh and eighth rows of each panel of Table OA.1, although weaker, are qualitatively similar to the results obtained using equal-weighted indices.

A.5 Style Controls

The TASS style classification, based on which our style index is constructed, may have some limitations. First, since the TASS classification is based on the self-reported styles of funds, it may be subject to errors and managerial manipulation. For example, if a fund classifies itself as one style while it is better described by another, our results may be due simply to the style effect as the style index fails to control for it. To address this possibility, we follow Pirinsky and Wang (2006) and include in the regression an additional style index (denoted by the superscript STY_b) that best describes the corresponding fund over the previous 24-month period, as measured by the R^2, from among the remaining 9 or 10 styles.[4] By using a rolling window of 24 months to compute the R^2, we also allow for the possibility that hedge funds switch styles over time (i.e., style drift). The results are presented in the ninth and tenth rows of each panel of Table OA.1, and show that adding this "best-fit" style index in the regression does not change much the magnitude and significance of the PB beta.[5]

Second, the TASS style classification defines some styles in a way that is too broad, so it may lump together funds that can differ in their true underlying (sub)styles (Sun, Wang, and Zheng 2012).[6] In this case, a fund in a broadly defined style category may load heavily on the PB index but not on the style index, if its PB specializes in servicing the substyle to which the fund belongs. Given that there are no data on substyle classification, this possibility is

[4]In an unreported work, we also use correlations, instead of R^2, as a criterion for selecting this additional style index and the results are similar.

[5]In an unreported work, we simply include in the regression all 10 or 11 available style indices (including the fund's corresponding style index, but excluding the market index to avoid multicollinearity) and obtain similar results.

[6]For example, Cassar and Gerakos (2011) note that the event-driven category in TASS and HFR covers at least three distinct style categories in CISDM.

essentially the self-selection hypothesis, with substyles being unobserved characteristics that drive both funds' PB selection and comovement among those that share such characteristics. To see whether our results are due to this (unobserved) substyle effect, we include in the regression a substyle index (denoted by the superscript STY_s), constructed using a subset of funds constituting the style index that best resemble the corresponding fund, as measured by the return correlation over the previous 24-month period (top decile).[7] By construction, this additional index controls for anything (observed or unobserved) that gives rise to return correlation but the TASS classification is too broad to capture. The results are presented in the last two rows of each panel of Table OA.1, and show that adding the substyle index in the regression does not change much the magnitude and significance of the PB beta.

B PB Merger and Changes of Portfolio Overlap

Given our finding in Section 3.2, one may wonder whether this finding is due to hedge funds exhibiting a higher degree of portfolio overlap following the merger of their PBs. Showing this will give extra credence to our finding in Section 3.2 in a way that is also suggestive of the information hypothesis. In this section, we check this possibility using 13F filings of hedge funds. One should note from the outset, however, that using 13F filings, we only examine overlap in quarterly long-equity positions, ignoring overlap in short or derivative positions and other intraquarter trading that may be contributing to the comovement we observe in monthly hedge fund returns. In addition, the fact that 13F filings are at the management company level (as opposed to the fund level) could cloud the identification of whether or not a given pair of hedge fund companies share common PB(s): It is easily conceivable that hedge fund companies that we identify as not sharing a PB might in fact share one or more PBs via funds that do not report to a hedge fund database. These features of 13F filings would have the effect of weakening our ability to reject the null hypothesis of no change in

[7] In an unreported work, we also construct a substyle index by matching on some observed characteristics such as style, size, and average past returns (as in Aragon and Strahan 2012) and obtain similar results.

portfolio overlap around PB mergers.

With this in mind, our empirical analysis proceeds as follows: First, we identify hedge fund companies among 13F filers by manually matching our sample to the Thomson database of institutional holdings (also called the s34 data set). We use our initial sample of 10,014 funds for which we have cleaned PB affiliation, instead of a final sample of 260 funds used in Section 3.2, in order to get a fuller picture of PB affiliations for a given hedge fund company, as well as to ensure enough sample hedge fund companies; as a result, we are able to identify 480 hedge fund companies among 13F filers. As in Section 3.2, we restrict the analysis to hedge fund companies serviced by a single PB, and discard PB changes that are nonmerger-related switches or those that are 8 quarters or less apart from each other. After requiring more than one hedge fund company per PB merger, our final sample of PB switching hedge fund companies consists of 67 hedge fund companies covering 6 different PB mergers.

Next, for a given merger, we compute portfolio overlap for every pair of hedge fund companies—within and across premerger PB groups—in each of the 16 quarters surrounding the merger (i.e., [-8, -1] and [1, 8], where -1 and +1 denote the quarter end immediately before and after the merger, respectively). Following Sias, Turtle, and Zykaj (forthcoming), we measure portfolio overlap by (1) the number of securities that each pair of hedge fund companies hold in common, (2) one minus the Bray and Curtis (1957) independence measure (henceforth, the portfolio independence metric), and (3) cosine similarity. The portfolio independence metric is given by

$$PI_{ij,t} = \frac{1}{2}\sum_{k=1}^{K} |w_{i,k,t} - w_{j,k,t}|,$$

where K is the total number of securities in the market in quarter t; $w_{i,k,t}$ is hedge fund company i's quarter t portfolio weight in security k; and $w_{j,k,t}$ is hedge fund company j's quarter t portfolio weight in security k. The cosine similarity is given by

$$s_{ij,t} = \sum_{k=1}^{K} w_{i,k,t} w_{j,k,t} \bigg/ \left(\sqrt{\sum_{k=1}^{K} w_{i,k,t}^2} \sqrt{\sum_{k=1}^{K} w_{j,k,t}^2} \right).$$

One minus the portfolio independence metric and consine similarity both range between zero and one, with a higher value indicating greater portfolio overlap. For example, if two hedge fund companies hold the same portfolio, both will equal one; whereas, if two hedge fund companies hold none of the same securities, both will equal zero.[8]

Finally, we pool the data and estimate a series of regressions with the following general structure:

$$Overlap_{ij,t} = b_0 + b_1\, Within_{ij} + b_2\, Post_t + b_3\, Within_{ij} \cdot Post_t + \varepsilon_{ij,t},$$

where $Overlap_{ij,t}$ is a measure of portfolio overlap between hedge fund companies i and j in quarter t; $Within_{ij}$ is an indicator variable for whether hedge fund companies i and j are within the same premerger PB group; and $Post_t$ is an indicator variable for whether the observation is after the merger. For brevity, we suppress the merger subscript.[9] Our key predictions here are that (1) before the merger, portfolio overlap within premerger PB groups is greater than portfolio overlap across premerger PB groups (i.e., $H_a : b_1 > 0$), and more importantly that (2) across-group portfolio overlap increases significantly after the merger (i.e., $H_a : b_2 > 0$). The interaction term is included to allow for (but not impose) different changes in portfolio overlap for within and across premerger PB groups around the

[8]As also pointed out by Sias et al. (forthcoming), however, the portfolio independence metric may fail to differentiate intuitively different levels of portfolio overlap. For example, if hedge fund company A holds 10%, 45%, and 45% of its portfolio in securities 1, 2, and 3, respectively, and hedge fund company B holds 10% and 90% in securities 1 and 4, respectively, then their portfolio independence metric is 90% (i.e., overlap is 10%). If hedge fund company B reduces its holdings in security 4 (not held by hedge fund company A) to 70% and increases its holdings in security 1 (held by hedge fund company A) to 30%, their portfolio independence metric does not change. In the meantime, however, their consine similarity increases from 1.71% to 6.11%.

[9]No hedge fund company pair in our sample experiences more than one PB merger.

merger: We predict that (3) changes in within-group portfolio overlap, if any, are smaller than changes in across-group portfolio overlap around the merger (i.e., $H_a : b_3 < 0$).

Table OA.3 reports pooled OLS regressions, where the units of observation are hedge fund company pair-quarter-merger. All regressions include quarter fixed effects to account for any general time trend in portfolio overlap. In our preferred regressions, we also include hedge fund company pair fixed effects to account for time-invariant differences in portfolio overlap across hedge fund company pairs. Other regressions use merger fixed effects or premerger PB group pair fixed effects. Note that $Within_{ij}$ is subsumed by premerger PB group pair fixed effects and by hedge fund company pair fixed effects. The results show that, despite our initial concerns discussed above, our predictions are fairly well supported by the data. Almost all estimated coefficients have the predicted signs (except one on $Within_{ij}$ in the second regression of one minus the portfolio independence metric) and the t-statistics often reject, at a 0.05 or more stringent significant level, the null hypothesis of no change in favor of the (one-sided) alternative represented by our predictions above.

To ensure that our statistical inference is robust to the fact that the dependent variable is a count variable or a fraction bounded between zero and one, we also employ a generalized linear model (GLM): For the number of common securities, we follow Hausman, Hall, and Griliches (1984) and assume a Poisson distribution and a log link. For one minus the portfolio independence metric and consine similarity, we follow Papke and Wooldridge (1996, 2008) and assume a binomial distribution and a logit link. These (unreported) regressions exhibit very similar pattern and levels of significance to the regressions reported in Table OA.3.

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TABLE OA.1: **PB-Level Comovement: Robustness Tests**

	Raw Returns						Filtered Returns					
	β^{PB}	β^{STY}	β^{STY_b}	β^{STY_s}	β^{MKT}	Adj. R^2	β^{PB}	β^{STY}	β^{STY_b}	β^{STY_s}	β^{MKT}	Adj. R^2
Panel A: Fund Fixed Effects and S.E. Clustered by Month												
PB Distress							0.39	0.71			-0.11	11.70
t-stat							13.67	32.92			-4.05	
36 months	0.43	0.40			0.15	19.05	0.41	0.26			0.21	8.23
t-stat	4.68	2.70			1.22		8.61	3.28			2.74	
0 month	0.56	0.29			0.12	21.99	0.54	0.18			0.21	9.84
t-stat	6.05	2.39			1.19		10.33	2.59			2.95	
Val. Weight	0.18	0.76			0.04	19.95	0.20	0.53			0.10	8.56
t-stat	7.49	12.09			0.84		9.10	8.99			2.90	
Best-Fit	0.42	0.51	0.14		-0.03	20.15	0.41	0.40	0.23		-0.07	9.89
t-stat	4.86	2.93	4.24		-0.22		8.75	4.25	5.07		-0.82	
Substyle	0.43	0.26		0.16	0.09	22.71	0.40	0.13		0.22	0.14	12.58
t-stat	3.86	9.24		1.33	0.94		6.03	5.45		2.08	2.25	
Panel B: S.E. Clustered by Month and Fund												
PB Distress							0.39	0.71			-0.12	9.33
t-stat							8.78	17.84			-2.37	
36 months	0.43	0.40			0.14	18.68	0.41	0.26			0.20	6.88
t-stat	4.63	2.64			1.13		8.14	3.14			2.47	
0 month	0.57	0.29			0.11	21.66	0.55	0.17			0.19	8.70
t-stat	5.61	2.30			1.01		7.87	2.37			2.36	
Val. Weight	0.18	0.76			0.04	19.60	0.19	0.53			0.10	7.32
t-stat	6.06	11.22			0.77		7.19	8.26			2.73	
Best-Fit	0.42	0.51	0.14		-0.03	18.85	0.40	0.40	0.23		-0.06	7.91
t-stat	4.56	2.87	3.83		-0.22		7.42	4.02	4.93		-0.73	
Substyle	0.43	0.27		0.16	0.09	22.41	0.40	0.14		0.21	0.14	11.59
t-stat	3.71	7.79		1.31	0.86		5.49	4.31		1.90	1.96	

This table reports the robustness of our results reported in Table 2 to various variations on our baseline specification. Panel A reports the results from panel regressions with fund fixed effects and standard errors clustered by month; Panel B reports the results from panel regressions with standard errors clustered by both month and fund. The first two rows of each panel include PB distress variables considered by Klaus and Rzepkowski (2009) in the initial filtering regressions, in addition to the Fung and Hsieh (2004) seven factors (81,849 observations). The third and fourth rows discard the PB information matched with return observations that precede the date as of which the PB information is current by more than 36 months (130,267 observations). The fifth and sixth rows discard the PB information matched with return observations that precede the date as of which the PB information is current at all (47,459 observations). The seventh and eighth rows use value weighting when computing the PB index and other independent variables in Equation (1) (155,361 observations). The ninth and tenth rows include an additional style index that best describes the corresponding fund out of the remaining 9 or 10 styles over the previous 24-month period in terms of the R^2 (149,794 observations). The last two rows include a substyle index, constructed using a subset of funds constituting the style index that best resemble the corresponding fund over the previous 24-month period (top decile) in terms of the return correlation (146,944 observations). Adjusted R^2s are in percentages.

TABLE OA.2: **Style Subsamples**

	Subsample restricted to								
	Convertible Arbitrage	Emerging Markets	Equity Market Neutral	Event Driven	Fixed Income Arbitrage	Global Macro	Long/Short Equity	Managed Futures	Multi-Strategy
Panel A: Fund Fixed Effects and S.E. Clustered by Month									
Raw Ret.	0.11	0.36	0.14	0.15	0.05	0.11	0.46	0.16	0.16
t-stat	2.54	4.89	3.15	6.66	1.83	1.74	2.84	4.51	5.65
Filtered Ret.	0.12	0.38	0.02	0.08	0.04	0.16	0.46	0.14	0.15
t-stat	2.62	7.63	0.52	3.61	1.14	3.84	7.16	3.39	4.48
Panel B: S.E. Clustered by Month and Fund									
Raw Ret.	0.10	0.35	0.14	0.15	0.04	0.11	0.46	0.16	0.16
t-stat	1.25	3.21	1.86	3.67	1.05	1.27	2.75	2.60	3.14
Filtered Ret.	0.11	0.34	0.02	0.08	0.02	0.15	0.46	0.12	0.15
t-stat	1.34	4.17	0.34	2.78	0.71	2.42	6.08	1.96	3.30

This table reports the PB betas estimated via Equation (1) for various style subsamples listed in the second row. Panel A reports the results from panel regressions with fund fixed effects and standard errors clustered by month; Panel B reports the results from panel regressions with standard errors clustered by both month and fund. The first two rows in each panel contain the results using raw excess returns; the next two rows contain the results using filtered returns. The number of sample funds used as the dependent variable is: 109 (convertible arbitrage), 237 (emerging markets), 170 (equity market neutral), 273 (event driven), 78 (fixed income arbitrage), 110 (global macro), 1168 (long/short equity), 237 (managed futures), and 183 (multi-strategy). Dedicated short bias and options strategy are dropped due to an insufficient number of funds.

TABLE OA.3: **PB Merger and Changes of Portfolio Overlap**

	Dependent Variable: $Overlap_{ij,t}$											
	Number of Common Securities				[1 - Portfolio Independence] (%)				Cosine Similarity (%)			
Constant	8.30	5.08	5.75	7.05	3.60	3.65	3.56	3.31	5.20	5.32	5.61	5.03
	(2.54)	(2.04)	(5.69)	(14.17)	(4.41)	(3.73)	(7.04)	(8.10)	(4.56)	(3.42)	(5.38)	(5.62)
$Within_{ij}$	0.06	0.71			0.25	-0.02			0.89	0.42		
	(0.02)	(0.29)			(0.32)	(-0.02)			(0.83)	(0.38)		
$Post_t$	0.62	4.53	4.99	4.85	0.18	1.26	1.33	0.88	1.24	2.96	3.08	2.41
	(0.41)	(3.95)	(4.25)	(4.33)	(0.30)	(2.69)	(2.78)	(2.02)	(1.05)	(2.90)	(2.99)	(2.37)
$Within_{ij} \cdot Post_t$	-4.41	-4.64	-5.19	-4.46	-0.86	-0.86	-0.94	-0.60	-2.30	-2.28	-2.42	-1.94
	(-3.16)	(-3.35)	(-3.62)	(-3.56)	(-1.67)	(-1.62)	(-1.76)	(-1.20)	(-1.99)	(-1.95)	(-2.06)	(-1.66)
Quarter FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Merger FE		✓				✓				✓		
Premerger PB group pair FE			✓				✓				✓	
Hedge fund company pair FE				✓				✓				✓
Adjusted R^2 (%)	2.52	3.82	6.40	71.34	0.83	1.31	2.23	64.58	0.63	1.01	2.25	53.64
Observations	6,882	6,882	6,882	6,882	6,882	6,882	6,882	6,882	6,882	6,882	6,882	6,882

This table reports pooled OLS regressions of hedge fund portfolio overlap around PB mergers. The dependent variable, $Overlap_{ij,t}$, is a measure of portfolio overlap between hedge fund companies i and j in quarter t. Measures of portfolio overlap include the number of securities that each pair of hedge fund companies hold in common, one minus the portfolio independence metric (in percentage), and cosine similarity (in percentage); and are computed in each of the 16 quarters surrounding the merger (i.e., [-8, -1] and [1, 8], where -1 and +1 denote the quarter end immediately before and after the merger, respectively). The independent variables are indicator variables for whether hedge fund companies i and j are within the same premerger PB group ($Within_{ij}$) and whether the observation is after the merger ($Post_t$). The units of observation are hedge fund company pair-quarter-merger, but the merger subscript is suppressed for brevity, as no hedge fund company pair in our sample experiences more than one PB merger. Quarter fixed effects are included in each regression, and merger, premerger PB group pair, and hedge fund company pair fixed effects are included where indicated. $Within_{ij}$ is subsumed by premerger PB group pair fixed effects and hedge fund company pair fixed effects. Standard errors are clustered by hedge fund company pair. The t-statistics are reported in parentheses.

TABLE OA.4: **Panel Regressions of Hedge Fund Performance on PB Betas**

Panel A: Standard Errors Clustered by Month and Fund

	Dependent Variable: Performance$_{t+1:t+12}$					
	Ex. Ret. (% p.m.)	Alpha (% p.m.)	SR	IR	MPPM$_3$ (% p.m.)	MPPM$_4$ (% p.m.)
$\beta^{PB}_{t-23:t}$	0.03	0.03	0.00	0.02	0.02	0.02
	(2.53)	(3.47)	(2.44)	(3.19)	(2.02)	(1.87)
Vol$_{t-23:t}$ (% p.m.)	0.08	0.03	-0.01	-0.04	-0.05	-0.09
	(4.86)	(2.15)	(-3.37)	(-5.28)	(-2.48)	(-4.18)
RedemptionNotice	0.06	0.04	0.07	0.13	0.07	0.08
	(2.75)	(1.88)	(3.37)	(2.97)	(2.88)	(2.91)
Lockup	0.00	0.01	0.00	0.01	0.00	0.00
	(1.44)	(2.64)	(1.54)	(1.71)	(0.34)	(0.09)
MgmtFee (%)	0.08	0.03	0.01	0.01	0.03	0.02
	(1.95)	(0.78)	(0.43)	(0.32)	(0.66)	(0.46)
IncentiveFee (%)	0.00	0.01	0.00	0.01	0.00	0.00
	(0.33)	(1.60)	(0.85)	(1.62)	(-0.46)	(-0.57)
log(Age$_t$)	-0.10	-0.09	-0.02	-0.02	-0.10	-0.10
	(-2.10)	(-1.85)	(-1.04)	(-0.57)	(-1.82)	(-1.73)
log(AUM$_t$)	-0.04	-0.02	0.00	0.00	-0.03	-0.03
	(-2.98)	(-1.25)	(-0.72)	(-0.03)	(-1.79)	(-1.49)
Flow$_{t-23:t}$ (%)	0.01	0.00	0.00	0.00	0.01	0.01
	(1.95)	(0.61)	(1.36)	(0.42)	(1.56)	(1.43)
$R_{t-23:t}$ (% p.m.)	-0.23	-0.06	-0.04	0.00	-0.23	-0.23
	(-4.60)	(-1.82)	(-3.69)	(-0.20)	(-4.43)	(-4.35)
log(1 + MinInvestment)	0.04	0.03	0.02	0.04	0.04	0.04
	(2.29)	(1.35)	(3.24)	(2.83)	(2.18)	(2.14)
PersonalCapital	0.06	0.01	-0.01	-0.05	0.05	0.05
	(1.59)	(0.31)	(-0.57)	(-1.30)	(1.31)	(1.17)
HighWaterMark	0.05	0.04	-0.03	-0.08	0.08	0.09
	(0.96)	(0.69)	(-1.41)	(-1.51)	(1.54)	(1.58)
Leveraged	0.07	0.06	0.04	0.09	0.05	0.05
	(1.86)	(1.35)	(2.80)	(2.29)	(1.20)	(1.05)
Offshore	-0.09	-0.03	-0.02	-0.02	-0.07	-0.07
	(-2.44)	(-0.80)	(-0.83)	(-0.35)	(-1.69)	(-1.51)
Adjusted R^2 (%)	4.81	0.77	8.69	5.26	3.58	4.67
Observations	97,249	97,249	97,249	97,249	97,249	97,249

(continued)

TABLE OA.4 (Continued): **Regressions of Hedge Fund Performance on PB Betas**

Panel B: Month Fixed Effects and Standard Errors Clustered by Month and Fund

	Dependent Variable: Performance$_{t+1:t+12}$					
	Ex. Ret. (% p.m.)	Alpha (% p.m.)	SR	IR	MPPM$_3$ (% p.m.)	MPPM$_4$ (% p.m.)
$\beta^{PB}_{t-23:t}$	0.03	0.03	0.01	0.02	0.03	0.03
	(2.89)	(3.50)	(2.84)	(3.22)	(2.45)	(2.29)
Vol$_{t-23:t}$ (% p.m.)	0.07	0.03	-0.02	-0.05	-0.07	-0.11
	(4.26)	(2.38)	(-5.77)	(-6.20)	(-3.64)	(-5.35)
RedemptionNotice	0.06	0.05	0.06	0.13	0.06	0.06
	(2.86)	(2.03)	(3.35)	(2.96)	(2.62)	(2.58)
Lockup	0.00	0.01	0.00	0.01	0.00	0.00
	(1.79)	(2.48)	(1.87)	(1.72)	(0.53)	(0.24)
MgmtFee (%)	0.08	0.03	0.01	0.01	0.04	0.03
	(2.12)	(0.74)	(0.66)	(0.47)	(0.83)	(0.64)
IncentiveFee (%)	0.00	0.01	0.00	0.01	0.00	0.00
	(0.06)	(1.27)	(0.68)	(1.39)	(-0.71)	(-0.81)
log(Age$_t$)	-0.02	-0.05	0.01	0.02	-0.03	-0.04
	(-0.55)	(-1.37)	(0.79)	(0.44)	(-0.83)	(-0.88)
log(AUM$_t$)	-0.02	-0.02	0.00	0.00	-0.01	-0.01
	(-2.06)	(-1.45)	(0.24)	(0.08)	(-0.78)	(-0.47)
Flow$_{t-23:t}$ (%)	0.00	0.00	0.00	0.00	0.00	0.00
	(0.61)	(0.37)	(0.02)	(-0.04)	(0.23)	(0.12)
$R_{t-23:t}$ (% p.m.)	-0.15	-0.02	-0.01	0.04	-0.13	-0.13
	(-3.49)	(-0.62)	(-1.03)	(2.54)	(-2.97)	(-2.83)
log(1 + MinInvestment)	0.03	0.03	0.02	0.04	0.02	0.02
	(1.90)	(1.41)	(2.93)	(2.71)	(1.67)	(1.59)
PersonalCapital	0.03	0.00	-0.02	-0.07	0.04	0.03
	(1.02)	(0.03)	(-1.14)	(-1.66)	(0.99)	(0.89)
HighWaterMark	0.12	0.04	-0.01	-0.05	0.15	0.16
	(3.06)	(0.93)	(-0.23)	(-0.94)	(3.44)	(3.39)
Leveraged	0.05	0.05	0.04	0.08	0.03	0.03
	(1.54)	(1.20)	(2.55)	(2.11)	(0.86)	(0.71)
Offshore	-0.05	-0.01	0.00	0.00	-0.04	-0.04
	(-1.33)	(-0.35)	(-0.03)	(0.09)	(-1.00)	(-0.92)
Adjusted R^2 (%)	19.74	4.25	22.96	9.08	20.47	21.50
Observations	97,249	97,249	97,249	97,249	97,249	97,249

This table reports the panel regression results for hedge fund performance on PB beta. Performance measures considered include average excess return (Ex. Ret.), Fung and Hsieh (2004) alpha, Sharpe ratio (SR), information ratio (IR), and the two manipulation-proof performance measures (MPPM$_3$ and MPPM$_4$), estimated over the 12-month period after PB betas are calculated. PB betas are calculated as in Table 5. Panel A of the table reports the results when standard errors are clustered by both month and fund; Panel B reports the results when month fixed effects are included in the regressions while standard errors are clustered by both month and fund. In any case, the regressions include style dummies, along with other control variables specified in the table. The extreme 1% of all variables are winsorized. The t-statistics are reported in parentheses.

TABLE OA.5: **Panel Regressions of Hedge Fund Performance on PB Betas: Crisis versus Noncrisis Windows**

Panel A: Standard Errors Clustered by Month and Fund

	Dependent Variable: Performance$_{t+1:t+12}$					
	Ex. Ret. (% p.m.)	Alpha (% p.m.)	SR	IR	MPPM$_3$ (% p.m.)	MPPM$_4$ (% p.m.)
$\beta^{PB}_{t-23:t} \cdot \text{Crisis}_{t-23:t}$	-0.02	0.01	0.00	0.01	-0.03	-0.04
	(-1.06)	(0.43)	(-0.64)	(0.99)	(-1.46)	(-1.51)
$\beta^{PB}_{t-23:t} \cdot \text{NonCrisis}_{t-23:t}$	0.05	0.05	0.01	0.02	0.05	0.05
	(3.96)	(3.91)	(3.42)	(3.15)	(4.03)	(4.04)
$\text{Vol}_{t-23:t}$ (% p.m.)	0.09	0.03	-0.01	-0.04	-0.03	-0.07
	(5.25)	(2.12)	(-2.38)	(-5.27)	(-1.57)	(-3.23)
RedemptionNotice	0.06	0.04	0.07	0.13	0.08	0.09
	(2.96)	(1.81)	(3.47)	(2.97)	(3.09)	(3.12)
Lockup	0.00	0.01	0.00	0.01	0.00	0.00
	(1.32)	(2.68)	(1.46)	(1.71)	(0.23)	(-0.01)
MgmtFee (%)	0.08	0.03	0.01	0.01	0.04	0.03
	(2.09)	(0.78)	(0.52)	(0.33)	(0.78)	(0.57)
IncentiveFee (%)	0.00	0.01	0.00	0.01	0.00	-0.01
	(-0.02)	(1.60)	(0.70)	(1.60)	(-0.83)	(-0.93)
$\log(\text{Age}_t)$	-0.09	-0.09	-0.01	-0.02	-0.09	-0.09
	(-1.99)	(-1.91)	(-0.94)	(-0.58)	(-1.69)	(-1.60)
$\log(\text{AUM}_t)$	-0.03	-0.02	0.00	0.00	-0.02	-0.02
	(-2.68)	(-1.30)	(-0.46)	(-0.02)	(-1.40)	(-1.08)
$\text{Flow}_{t-23:t}$ (%)	0.01	0.00	0.00	0.00	0.00	0.00
	(1.58)	(0.64)	(1.07)	(0.40)	(1.10)	(0.94)
$R_{t-23:t}$ (% p.m.)	-0.25	-0.06	-0.04	0.00	-0.26	-0.27
	(-4.96)	(-1.87)	(-4.18)	(-0.28)	(-4.93)	(-4.89)
$\log(1 + \text{MinInvestment})$	0.04	0.03	0.02	0.04	0.04	0.04
	(2.35)	(1.40)	(3.29)	(2.85)	(2.23)	(2.17)
PersonalCapital	0.05	0.01	-0.01	-0.05	0.05	0.05
	(1.49)	(0.33)	(-0.63)	(-1.30)	(1.18)	(1.03)
HighWaterMark	0.06	0.03	-0.03	-0.08	0.11	0.12
	(1.32)	(0.62)	(-1.23)	(-1.51)	(2.04)	(2.09)
Leveraged	0.06	0.06	0.04	0.09	0.04	0.04
	(1.71)	(1.37)	(2.71)	(2.29)	(1.00)	(0.85)
Offshore	-0.08	-0.04	-0.01	-0.02	-0.06	-0.06
	(-2.12)	(-0.83)	(-0.69)	(-0.34)	(-1.33)	(-1.15)
Adjusted R^2 (%)	12.11	3.32	24.45	12.15	4.90	5.80
Observations	97,249	97,249	97,249	97,249	97,249	97,249

(continued)

TABLE OA.5 (Continued): **Panel Regressions of Hedge Fund Performance on PB Betas: Crisis versus Noncrisis Windows**

Panel B: Month Fixed Effects and Standard Errors Clustered by Month and Fund

	Dependent Variable: Performance$_{t+1:t+12}$					
	Ex. Ret. (% p.m.)	Alpha (% p.m.)	SR	IR	MPPM$_3$ (% p.m.)	MPPM$_4$ (% p.m.)
$\beta^{PB}_{t-23:t} \cdot \text{Crisis}_{t-23:t}$	-0.01	0.01	0.00	0.01	-0.02	-0.03
	(-0.80)	(0.39)	(0.01)	(1.21)	(-1.12)	(-1.16)
$\beta^{PB}_{t-23:t} \cdot \text{NonCrisis}_{t-23:t}$	0.04	0.05	0.01	0.02	0.05	0.05
	(4.19)	(4.00)	(3.54)	(3.07)	(4.29)	(4.29)
Vol$_{t-23:t}$ (% p.m.)	0.07	0.03	-0.02	-0.05	-0.07	-0.11
	(4.38)	(2.44)	(-5.73)	(-6.18)	(-3.59)	(-5.31)
RedemptionNotice	0.06	0.05	0.06	0.13	0.06	0.06
	(2.84)	(2.02)	(3.35)	(2.96)	(2.60)	(2.56)
Lockup	0.00	0.01	0.00	0.01	0.00	0.00
	(1.83)	(2.51)	(1.88)	(1.73)	(0.57)	(0.28)
MgmtFee (%)	0.08	0.03	0.01	0.01	0.04	0.03
	(2.16)	(0.75)	(0.67)	(0.47)	(0.86)	(0.66)
IncentiveFee (%)	0.00	0.01	0.00	0.01	0.00	0.00
	(0.01)	(1.24)	(0.67)	(1.39)	(-0.77)	(-0.86)
log(Age$_t$)	-0.02	-0.05	0.01	0.02	-0.04	-0.04
	(-0.63)	(-1.43)	(0.77)	(0.43)	(-0.92)	(-0.96)
log(AUM$_t$)	-0.02	-0.02	0.00	0.00	-0.01	-0.01
	(-2.04)	(-1.44)	(0.25)	(0.08)	(-0.76)	(-0.45)
Flow$_{t-23:t}$ (%)	0.00	0.00	0.00	0.00	0.00	0.00
	(0.58)	(0.36)	(0.01)	(-0.05)	(0.20)	(0.09)
$R_{t-23:t}$ (% p.m.)	-0.15	-0.02	-0.01	0.04	-0.14	-0.14
	(-3.57)	(-0.69)	(-1.08)	(2.51)	(-3.07)	(-2.93)
log(1 + MinInvestment)	0.03	0.03	0.02	0.04	0.02	0.02
	(2.00)	(1.46)	(2.98)	(2.73)	(1.77)	(1.67)
PersonalCapital	0.03	0.00	-0.02	-0.06	0.04	0.04
	(1.05)	(0.05)	(-1.14)	(-1.66)	(1.02)	(0.92)
HighWaterMark	0.12	0.04	-0.01	-0.05	0.15	0.15
	(3.01)	(0.89)	(-0.25)	(-0.95)	(3.38)	(3.33)
Leveraged	0.05	0.05	0.04	0.08	0.03	0.03
	(1.54)	(1.20)	(2.55)	(2.12)	(0.86)	(0.71)
Offshore	-0.05	-0.01	0.00	0.00	-0.04	-0.04
	(-1.34)	(-0.36)	(-0.04)	(0.09)	(-1.01)	(-0.93)
Adjusted R^2 (%)	19.86	4.28	22.98	9.08	20.60	21.63
Observations	97,249	97,249	97,249	97,249	97,249	97,249

This table reestimates the regressions in Table OA.4 by allowing a different coefficient on PB beta, depending on whether the 24-month window over which PB beta is estimated overlaps with the following crisis periods: September–November 1998 (Long-Term Capital Management crisis), August–October 2007 (Quant crisis), and September–November 2008 (financial crisis). Crisis$_{t-23:t}$ equals one if the 24-month window overlaps with the crisis periods and zero otherwise; and NonCrisis$_{t-23:t}$ equals one if the 24-month window does not overlap with the crisis periods and zero otherwise.

TABLE OA.6: **Panel Regressions of Hedge Fund Performance on PB Betas: Crisis versus Noncrisis Windows and Leveraged versus Unleveraged Funds**

Panel A: Standard Errors Clustered by Month and Fund

	Dependent Variable: Performance$_{t+1:t+12}$					
	Ex. Ret. (% p.m.)	Alpha (% p.m.)	SR	IR	MPPM$_3$ (% p.m.)	MPPM$_4$ (% p.m.)
$\beta^{PB}_{t-23:t}$ · Crisis$_{t-23:t}$ · Leveraged	-0.05	0.00	-0.01	0.00	-0.07	-0.08
	(-1.98)	(0.18)	(-1.48)	(0.34)	(-2.48)	(-2.53)
$\beta^{PB}_{t-23:t}$ · Crisis$_{t-23:t}$ · Unleveraged	0.05	0.02	0.01	0.03	0.07	0.07
	(1.49)	(0.55)	(1.38)	(1.39)	(1.46)	(1.42)
$\beta^{PB}_{t-23:t}$ · NonCrisis$_{t-23:t}$ · Leveraged	0.05	0.05	0.01	0.02	0.05	0.05
	(3.58)	(3.83)	(2.77)	(2.54)	(3.47)	(3.44)
$\beta^{PB}_{t-23:t}$ · NonCrisis$_{t-23:t}$ · Unleveraged	0.03	0.02	0.01	0.02	0.04	0.05
	(1.93)	(1.02)	(2.21)	(1.98)	(2.37)	(2.46)
Adjusted R^2 (%)	12.28	3.39	24.52	12.18	5.08	5.99
Observations	97,249	97,249	97,249	97,249	97,249	97,249

Panel B: Month Fixed Effects and Standard Errors Clustered by Month and Fund

	Dependent Variable: Performance$_{t+1:t+12}$					
	Ex. Ret. (% p.m.)	Alpha (% p.m.)	SR	IR	MPPM$_3$ (% p.m.)	MPPM$_4$ (% p.m.)
$\beta^{PB}_{t-23:t}$ · Crisis$_{t-23:t}$ · Leveraged	-0.04	0.00	0.00	0.01	-0.05	-0.06
	(-1.69)	(0.16)	(-0.76)	(0.59)	(-2.13)	(-2.17)
$\beta^{PB}_{t-23:t}$ · Crisis$_{t-23:t}$ · Unleveraged	0.05	0.02	0.01	0.03	0.06	0.07
	(1.50)	(0.51)	(1.52)	(1.44)	(1.60)	(1.57)
$\beta^{PB}_{t-23:t}$ · NonCrisis$_{t-23:t}$ · Leveraged	0.05	0.06	0.01	0.02	0.05	0.05
	(3.97)	(3.99)	(3.14)	(2.58)	(3.85)	(3.82)
$\beta^{PB}_{t-23:t}$ · NonCrisis$_{t-23:t}$ · Unleveraged	0.03	0.02	0.01	0.02	0.04	0.04
	(1.72)	(0.94)	(1.75)	(1.75)	(2.20)	(2.28)
Adjusted R^2 (%)	19.99	4.35	23.03	9.11	20.73	21.76
Observations	97249	97,249	97,249	97,249	97,249	97,249

This table reestimates the regressions in Table OA.4 by allowing a different coefficient on PB beta, depending on whether the fund uses leverage, as well as whether the 24-month window over which PB beta is estimated overlaps with the following crisis periods: September–November 1998 (Long-Term Capital Management crisis), August–October 2007 (Quant crisis), and September–November 2008 (financial crisis). Crisis$_{t-23:t}$ equals one if the 24-month window overlaps with the crisis periods and zero otherwise; and NonCrisis$_{t-23:t}$ equals one if the 24-month window does not overlap with the crisis periods and zero otherwise. The reported regressions include the same set of control variables as in Table OA.4, though not reported here for brevity.