The Role of CAT Bonds in an International Multi-Asset Portfolio: Diversifier, Hedge, or Safe Haven?

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Abstract

We examine whether CAT bonds can serve as a hedge or a safe haven for global stock, bond, real estate, commodity, private equity, and infrastructure markets. Our results indicate that CAT bonds are a poor hedge, but they act as an effective diversifier against all asset classes under investigation. Moreover, CAT bonds can serve as a strong safe haven against extreme price drops of stocks only during the post-crisis period.

JEL Classification: G11, G15

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1. Introduction

During the past decade, catastrophe (CAT) bonds have gained in popularity, and institutional investors have embraced CAT bonds as a new asset class (Sterge and van der Stichele, 2016). CAT bonds are often considered as "zero-beta" investments, i.e., their structures segregate investors from market-related risk and expose them only to event-driven risk. Therefore, they may offer investors valuable sources of portfolio diversification (Litzenberger et al., 1996).

However, systematic risk in CAT bonds seems to vary over time. Carayannopoulos and Perez (2015) document that CAT bonds are zero-beta assets only in non-crisis periods. Nevertheless, they also show that the effect of the financial crisis on CAT bonds returns, compared to stocks and bonds, is relatively small, suggesting that CAT bonds still offer valuable diversification benefits during market downturns. Taking the multi-asset portfolio perspective, Clark et al. (2016), Kish (2016), and Sterge and van der Stichele (2016) all confirm that CAT bonds provide diversification benefits when added to an investor's portfolio comprising stocks, bonds, commodities, and real estate. Their empirical results further reveal that CAT bonds can reduce drawdown measures and tail risk under various market regimes.

The prior literature has so far neglected the potential role of CAT bonds as a safe haven investment. Existing empirical evidence does not allow for a differentiated view on the diversification potential of CAT bonds versus their hedging or safe haven properties. We address this gap by investigating to what extent CAT bonds can serve as a diversifier, hedge, or safe haven against large price movements in different asset classes such as stock, bond, real estate, commodities, private equity, and infrastructure.

Following the definitions of Baur and Lucey (2010), Ratner and Chiu (2013), and Bouri et al. (2017), a diversifier describes an asset that has only a weak positive correlation with another asset. In contrast, an asset that is, on average, uncorrelated (or even negatively correlated) with another asset is referred to as a weak (or strong) hedge. Finally, an asset that is uncorrelated (or negatively correlated) with another asset during times of stress or crisis is classified as a weak (or strong) safe haven. In order to assess CAT bonds according to this three-category scheme, we apply the empirical methodology of Ratner and Chiu (2013) and Bouri et al. (2017), which draws on Engle's (2002) dynamic conditional correlation (DCC) model.

Our results indicate that CAT bonds, in this terminology, are a poor hedge, but they are able to act as an effective diversifier against all asset classes under investigation. Moreover, CAT bonds can serve as a strong safe haven against extreme down price movements of stocks only during the post-crisis period.

2. The CAT bond market

Since the early 1990s, insurance and reinsurance companies have been developing and utilizing insurance-linked securities to bridge capacity gaps in reinsurance and to protect against peak losses from natural disasters. The most prominent and successful type of these alternative risk transfer tools are catastrophe (CAT) bonds, ceding natural disaster risk to capital markets, and enabling risk to be traded over the counter.

CAT bonds are fully collateralized floating-rate fixed-income instruments, which are issued out of a special purpose vehicle (SPV), holding the principal paid by investors.[1] They usually mature in three to four years. The sponsor transfers the risks to and enters into a reinsurance contract with the SPV. In case of a predetermined catastrophic event (or peril), meeting the trigger conditions defined in the bond indenture, the sponsor is refunded with the proceeds of the collateral to cover its losses. Investors are compensated for taking over the risk through regular coupons, which are usually floating returns based on LIBOR plus a risk premium. If no trigger event occurs until maturity, the principal is returned to the investors.

[1] See Kish (2016) and Sterge and van der Stichele (2016) for a detailed overview of the structure of CAT bonds.

Due to their structure, CAT bonds are expected to isolate investors from market risks such as equity market volatility and credit risk (counterparty risk). The occurrence of natural disasters is uncorrelated with the global financial markets, which in turn suggests that CAT bond performance is independent of financial market performance (Litzenberger et al., 1996; Carayannopoulos and Perez, 2015). Besides the comparably high interest rates they offer, this often referred to as zero-beta characteristic of CAT bonds is an attractive feature to investors during bear market periods, and makes them an interesting investment opportunity in low interest environments. From the issuers' perspective, CAT bonds reduce the reserve requirement, increase its insurance protection, and pose a negligible credit risk (Edesess, 2015).

To emphasize the increased relevance of the global CAT bond market, Figure 1 shows the development of outstanding CAT bond volume from 2002 through 2017 by peril in m$.[2] We recognize a substantial increase in outstanding risk capital from about $2.2 bn in 2002 to $23 bn in June 2017. Thereby, wind and multi-peril bonds account for most of the outstanding market volume. Evaluating the overall pattern of the outstanding CAT bond volume, we note a relatively cyclical behavior, with a decrease in new issuances during the aftermath of the financial crisis. The observed issuance waves are comparable to the behavior also documented for other types of securities such as stocks and bonds (Henderson et al., 2006).

[Insert Figure 1 here]

3. Data and preliminary analysis

To investigate the potential role of CAT bonds as a hedge or a safe haven against six other asset classes, we rely on the Swiss Re Global Unhedged CAT Bond Performance Index. The index measures the movement of secondary bid indications, as provided by Swiss Re in their

[2] The data was kindly provided by Lane Financial LLC.

weekly pricing indications to investors, and is a widely-used proxy for the overall CAT bond market performance.[3]

The other asset classes that we consider in our analysis are represented by: (1) the MSCI World Investable Market Index to gain exposure to the world stock market; (2) the J.P. Morgan GBI Broad Index to capture global government bonds; (3) the GPR 250 Index to measure global listed real estate; (4) the Thomson Reuters/Core Commodity CRB Index as a proxy for commodities; (5) the LPX 50 Index for global listed private equity; and (6) the NMX 30 Index to incorporate global infrastructure investments. All indices are total return indices and denominated in USD. We use continuously compounded returns on a weekly basis, and our sample period spans from January 2002 to December 2018.

We conduct a robustness check to investigate the properties of CAT bonds before and after the financial crisis of 2008. For this purpose, we divide the observation period into two subperiods: (i) the pre-crisis period January 2002-December 2008, and (ii) the post-crisis period January 2009-December 2018.

[Insert Figure 2 here]

Figure 2 provides a graphical comparison of CAT bond index development with the performance of the six other asset classes under investigation. We note from Figure 2 that CAT bonds performed reasonably well during our sample period. Only infrastructure and real estate investment provided superior returns. Most notably, CAT bonds exhibit the lowest volatility of all performance series. Further summary statistics of a sample of assets are contained in Table 1. As expected, CAT bonds exhibit the highest kurtosis, boasting the highest tail risk, especially during the full and post-crisis period. This observation corroborates the notion that reinsurance

[3] See Swiss Re (2014) for a detailed description of the index, which has become the industry's key point of reference for CAT bonds.

firms have higher exposure to catastrophe tail risks due to large losses associated with infrequent but catastrophic natural disasters (Hagendorff et al., 2014; Trottier et al., 2019).

What is also apparent are the significant negative first order autocorrelations of CAT bond returns during the full sample period (Panel A) and the post-crisis period (Panel C). Since the valuation in the Swiss Re Global Unhedged CAT Bond Performance Index is based on indicative pricing, all returns tend to be smoothed through time, which in turn shows up as negative autocorrelation and low volatility. Negative autocorrelation generates a tendency for overvaluation, which in turn is likely followed by an adjustment in the next period. Moreover, significant autocorrelations lead to biased estimates of the standard deviation. As a robustness check, we therefore use Geltner's (1993) approach to derive de-smoothed time series and then re-estimate our model. The standard deviation of the de-smoothed series decrease (increase) when the first order autocorrelation coefficient is negative (positive). Given that in our case the first order autocorrelation coefficients are negative, the transformation generates lower standard deviations for CAT bonds, while their mean return remains unchanged.

4. Methodology

Following the approach in Ratner and Chiu (2013) and Bouri et al. (2017), we implement our empirical tests in two stages. In the first stage, we estimate pairwise dynamic conditional correlations (DCCs) between the CAT bond index and each of the other six asset class indices. In the second stage, we run regressions to evaluate the hedge and safe haven properties of CAT bonds against the other asset classes.

To estimate the pairwise dynamic conditional correlations (DCCs) between the CAT bond index and each of the other six asset class indices, we use the DCC model proposed by Engle (2002). The estimation of the DCC model works in two steps. First, a univariate GARCH (1,1) model is estimated. Second, a time-varying correlation matrix is computed using the standardized residuals from the first-step estimation. The mean equation of the DCC model is:

$$r_t = \mu_t + \omega\, r_{t-1} + \varepsilon_t \tag{1}$$

where r_t denotes the vector of CAT bond returns and that of the other asset class at time t; μ_t denotes the conditional mean vector of r_t; ω is the autoregressive coefficient; and ε_t is a vector of residuals. The conditional variance equation is:

$$h_t = c + a\, \varepsilon_{t-1}^2 + b\, h_{t-1} \tag{2}$$

where h_t denotes the conditional variance; c is the constant; a denotes the parameter for the ARCH effect; and b denotes the GARCH effect. Next, the DCC (1,1) equation is described by the time-varying correlation matrix Q_t:

$$Q_t = (1 - \alpha - \beta)\bar{Q} + \alpha\varepsilon_{t-1}\varepsilon_{t-1}' + \beta Q_{t-1} \tag{3}$$

where Q_t denotes the conditional variance-covariance matrix of the residuals ε_t, and $\bar{Q}$ is its unconditional counterpart. ε_t denotes a vector of residuals received from the first step estimation of the GARCH (1,1) process, and α and β are scalar parameters to capture the effects of previous shocks and previous DCCs on the current DCC. Finally, the DCC between assets i and j at time t is given as:

$$\rho_{ij,t} = \frac{q_{ij,t}}{\sqrt{q_{ii,t}}\sqrt{q_{jj,t}}} \tag{4}$$

In a second step, we extract the DCCs from the DCC model above into separate time series and regress the pairwise DCCs on dummy variables (D) that capture extreme price movements at the 10%, 5%, and 1% quantiles (q) of the most negative returns of a respective asset class:

$$\begin{aligned} DCC_t = \ & m_0 + m_1 D\left(r_{other\ asset\ q10}\right) + m_2 D\left(r_{other\ asset\ q5}\right) \\ & + m_3 D\left(r_{other\ asset\ q1}\right) + v_t \end{aligned} \tag{5}$$

The estimates in equation (5) allow interpretations of the role of CAT bonds, which provide answers to our research question. In particular, if the m_0 coefficient is significantly positive, CAT bonds are a diversifier against movements in the respective asset. Conversely, if the m_0 coefficient is zero (negative), CAT bonds are a weak (strong) hedge against movements in the respective asset. CAT bonds can serve as a weak safe haven for the respective asset class under investigation asset if the m_1, m_2, and m_3 coefficients are insignificantly different from zero, or they are a strong safe haven if these estimates are statistically significant negative.

5. Empirical results

5.1. The DCC model

The objective of DCC modeling is to extract estimates for the pairwise DCCs between CAT bonds and a specific asset class. Therefore, we do not present the DCC GARCH results in detail, but merely focus on the results for our core analysis. However, we conduct diagnostic tests on the standardized and squared residuals by applying an ARCH-LM test and analyzing the Ljung-Box Q-statistics. The results indicate that our model provides a good fit to the data. In the variance and DCC equations, the estimated coefficients are significant at the 1% level in nearly all cases. With the exception of CAT bonds, the estimated ARCH coefficient is much smaller than the GARCH coefficient, thus own long-run volatility persistence is larger than short-run persistence; the opposite holds for CAT bonds. In addition (again with the exception of CAT bonds), the sum of the ARCH and GARCH parameters in the variance equation is close to one, indicating that the variance process is highly persistent. The α and β estimates are both statistically significant at the 1% level in all cases, reflecting time-varying correlations. Moreover, the sum of the DCC coefficients α and β is less than one, fulfilling the condition that $\alpha + \beta < 1$. Finally, the Engle and Sheppard (2001) λ^2-test rejects the null hypothesis of constant conditional correlations at the 1% significance level in all cases, thus supporting the use of the

DCC-GARCH model in the analysis of the return series instead of Bollerslev's (1990) constant conditional correlation model.

5.2. Hedge and safe haven properties of CAT bonds

Table 2 summarizes the dummy regression estimates from equation (4) using the original (smoothed) CAT bond returns. CAT bonds cannot act as a strong or weak safe haven in phases of extreme market declines of the other six asset classes during both the full and the pre-crisis period. The positive and significant coefficients m_1 for stocks, m_2 for real estate, and both m_2 and m_3 for commodities within the full period (Panel A) only demonstrate that CAT bonds are an effective diversifier within the respective quantiles of the return distribution. The same holds true for the significantly positive m_2 coefficients for stocks, commodities, private equity, and infrastructure during the pre-crisis period (Panel B). For the post-crisis period (Panel C), only the m_2 coefficient for stocks is negative and statistically significant at the 10% level, indicating that in this particular case CAT bonds are a strong safe haven within the 10% stock quantile. Turning to the model constant m_0, all estimated coefficients show a positive sign with statistical significance at the 1% level. This result indicates that CAT bonds should not be viewed as a hedge against movements in the respective asset classes, albeit as an effective diversifier.

[Insert Table 2 here]

Table 3 shows the result for the same analyses, but now using the de-smoothed CAT bond returns. The results remain virtually unchanged. Again, a noteworthy observation is that regression coefficient m_2 for stocks during the post-crisis period (Panel C) is negative and now statistical significant even at the 5% level. The findings in Carayannopoulos and Perez (2015) and Gürtler et al. (2016) could provide an explanation. On the one hand, Carayannopoulos and Perez (2015) document that CAT bonds were strongly affected by the subprime financial crisis, which can be attributed to weaknesses associated with the composition and the structure of the trust account. In particular, assets used as collateral in the trust account turned out to be of lesser quality than thought initially. In addition, counterparties in swap agreements, put in place in an effort to immunize collateral asset returns from market fluctuations, were exposed to substantial credit risk or even defaulted during the crisis. On the other hand, Gürtler et al. (2016) document that CAT bond premiums depend on capital market developments, as measured by corporate bond spreads, and this positive dependence significantly reinforced after the bankruptcy of Lehman Brothers that caused the financial crisis. As a result, CAT bonds are not immune to changes in systematic risk and exhibit a behavior that is not consistent with a zero-beta investment.

[Insert Table 3 here]

6. Conclusion

Despite the growing importance of CAT bonds for investors as a valuable source of diversification, prior studies provide no evidence on their diversification, hedging, and safe haven properties against other asset classes. Using weekly return data, we employ Engle's (2002) DCC model and document that CAT bonds serve as an effective diversifier against all asset classes under investigation. With respect to the safe haven characteristics of CAT bonds, we find – with the exception of stocks during the post-crisis period – no evidence that CAT bonds are qualified as a safe haven investment against extreme price movements in other asset classes. Nevertheless, despite of the fact that CAT bonds cannot act as a safe haven in phases of extreme market declines, they are still an effective diversifier within a multi-asset portfolio. Our findings have important implications for institutional investors, for their hedging strategies, and for their approaches to compose portfolios in times of market stress.

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Figure 1: CAT bonds outstanding by peril

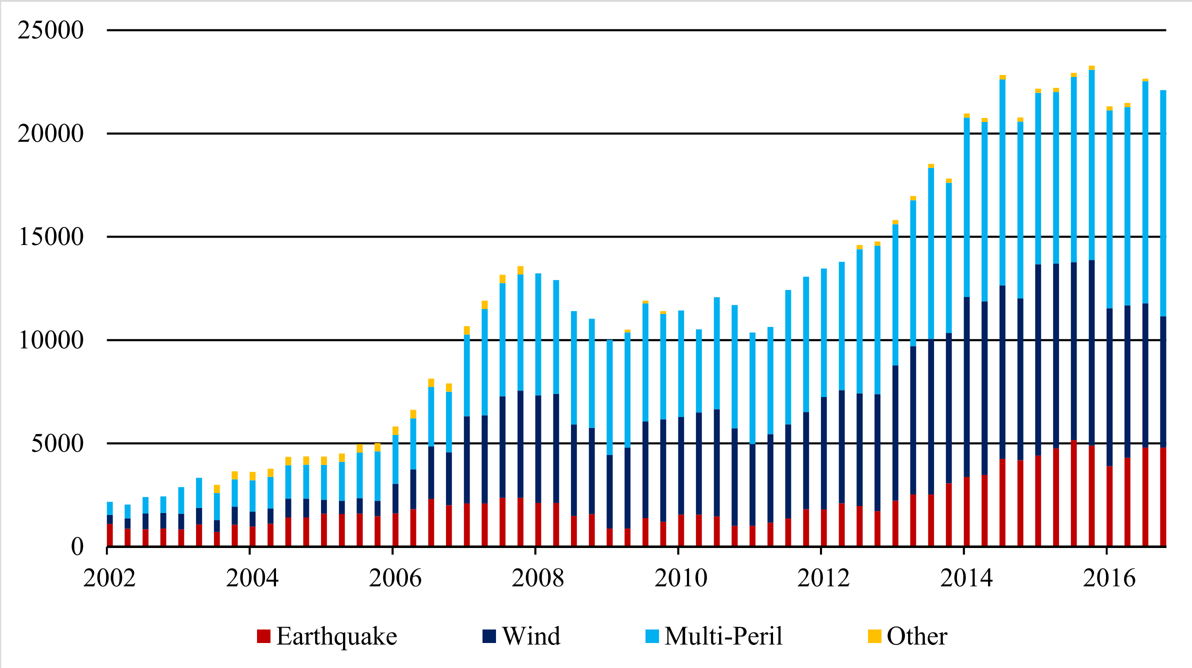

Figure 2: Performance indices (January 2002 – December 2018)

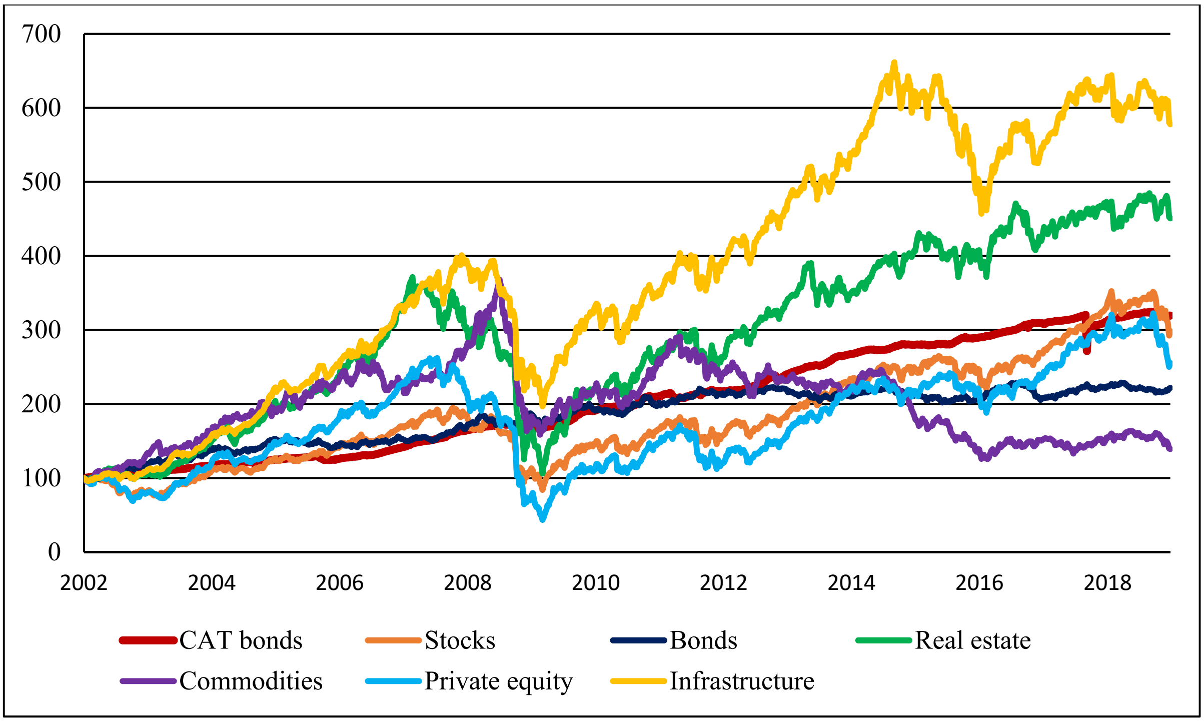

Table 1: Summary statistics

	Mean (%)	Max. (%)	Min. (%)	SD (%)	Skewness	Kurtosis	AC (1)	AC (2)
Panel A: full period January 2002 to December 2018 (885 observations)								
CAT bonds	0.13	10.90	-16.58	0.76	-8.98	313.51	-0.34**	-0.01
CAT bonds (desmoothed)	0.13	3.88	-12.20	0.53	-13.84	335.51	-0.05	-0.12**
Stocks	0.13	11.71	-22.04	2.35	-1.29	14.03	-0.01	0.05
Bonds	0.09	3.86	-3.15	0.95	-0.05	3.43	-0.01	0.03
Real estate	0.17	17.63	-18.22	2.65	-0.96	12.30	0.03	0.06
Commodities	0.04	8.44	-16.06	2.40	-0.86	6.99	-0.01	0.02
Private equity	0.11	14.23	-33.92	3.32	-2.13	21.34	0.05	0.13**
Infrastructure	0.20	9.52	-24.82	2.23	-2.09	22.77	-0.08**	0.05
Panel B: pre-crisis period January 2002 to December 2008 (364 observations)								
CAT bonds	0.14	3.62	-2.89	0.39	-1.07	38.80	-0.03	0.05
CAT bonds (desmoothed)	0.14	3.43	-2.83	0.38	-1.31	37.79	0.00*	0.05
Stocks	0.04	11.71	-22.04	2.57	-1.91	19.75	-0.02	0.12
Bonds	0.17	3.86	-3.11	1.06	-0.07	3.00	0.01	0.04
Real estate	0.14	17.63	-18.22	2.95	-1.38	15.27	0.03	0.07
Commodities	0.17	8.44	-16.06	2.77	-1.21	7.76	-0.06	0.08
Private equity	-0.07	14.23	-33.92	3.61	-3.49	30.75	0.03	0.18**
Infrastructure	0.26	9.52	-24.82	2.47	-3.20	33.79	-0.17**	0.16**
Panel C: post-crisis period January 2009 to December 2018 (520 observations)								
CAT bonds	0.12	10.90	-16.58	0.93	-8.11	231.24	-0.38**	-0.02
CAT bonds (desmoothed)	0.12	3.61	-11.83	0.63	-13.01	262.02	-0.08	-0.17**
Stocks	0.19	8.16	-9.23	2.18	-0.55	5.30	-0.01	-0.01
Bonds	0.03	3.44	-3.15	0.86	-0.12	3.78	-0.05	-0.00
Real estate	0.20	11.35	-10.91	2.42	-0.39	6.46	0.02	0.05
Commodities	-0.05	6.87	-9.39	2.10	-0.34	4.20	0.05	-0.04
Private equity	0.22	13.93	-14.53	3.10	-0.58	7.65	0.07	0.12**
Infrastructure	0.16	5.57	-9.10	2.05	-0.68	4.76	0.01	-0.06

*Notes: All numbers are based on weekly continuously compounded returns. ***, ** and * denote significance at the 1%, 5%, and 10% levels, respectively.*

Table 2: Hedge and safe haven properties of smoothed CAT bonds returns

	10% quantile (m_1)	5% quantile (m_2)	1% quantile (m_3)	Hedge (m_0)
Panel A: full period January 2002 to December 2018 (884 observations)				
Stocks	0.0476**	-0.0396	0.0827	0.1118***
Bonds	0.0067	0.0190	0.0238	0.0679***
Real estate	-0.0160	0.0692**	0.0109	0.0993***
Commodities	-0.0029	0.0530*	0.1573***	0.1211***
Private equity	0.0226	0.0081	0.0518	0.1285***
Infrastructure	-0.0178	0.0543	0.0609	0.1269***
Panel B: pre-crisis period January 2002 to December 2008 (363 observations)				
Stocks	0.0081	0.0724*	-0.0463	0.2418***
Bonds	-0.0061	-0.0146	0.1354	0.1393***
Real estate	0.0038	0.0266	-0.0480	0.2312***
Commodities	0.0271	0.0811*	0.0378	0.2543***
Private equity	-0.0365	0.1244***	-0.0777	0.2736***
Infrastructure	0.0206	0.1060**	-0.0391	0.2875***
Panel C: post-crisis period January 2009 to December 2018 (519 observations)				
Stocks	0.0385	-0.0913*	0.0999	0.1019***
Bonds	0.0282	0.0039	0.0199	0.0560***
Real estate	-0.0334	0.0383	0.0125	0.0860***
Commodities	0.0109	-0.0374	0.0727	0.1082***
Private equity	0.0038	-0.0126	0.0611	0.1161***
Infrastructure	-0.0296	-0.0482	0.1438*	0.1044***

*Notes: This table reports the results of the dummy regression model from equation 5. All estimated are based on weekly continuously compounded returns. ***, ** and * denote significance at the 1%, 5%, and 10% levels, respectively.*

Table 3: Hedge and safe haven properties of de-smoothed CAT bonds returns

	10% quantile (m_1)	5% quantile (m_2)	1% quantile (m_3)	Hedge (m_0)
Panel A: full period January 2002 to December 2018 (884 observations)				
Stocks	0.0576**	-0.0419	0.0395	0.1153***
Bonds	0.0123	0.0184	-0.0042	0.1063***
Real estate	-0.0088	0.0702**	-0.0432	0.1070***
Commodities	0.0062	0.0696**	0.1563***	0.1323***
Private equity	0.0427**	0.0032	0.0211	0.1360***
Infrastructure	-0.0136	0.0532	0.0867	0.1353***
Panel B: pre-crisis period January 2002 to December 2008 (363 observations)				
Stocks	0.0081	0.0719*	-0.0466	0.2414***
Bonds	-0.0058	-0.0150	0.1359	0.1387***
Real estate	0.0039	0.0262	-0.04843	0.2305***
Commodities	0.0270	0.0814*	0.0374	0.2535***
Private equity	-0.0364	0.1240***	-0.0782	0.2732***
Infrastructure	0.0207	0.1054**	-0.0393	0.2874***
Panel C: post-crisis period January 2009 to December 2018 (520 observations)				
Stocks	0.0466	-0.1011**	0.0909	0.0975***
Bonds	0.0291	-0.0016	0.0218	0.0569***
Real estate	-0.0274	0.0470	-0.0244	0.0770***
Commodities	0.0116	-0.0468	0.0713	0.1021***
Private equity	0.0132	-0.0241	0.0519	0.1129***
Infrastructure	-0.0341	-0.0430	0.1342*	0.0955***

*Notes: This table reports the results of the dummy regression model from equation 5. All estimated are based on weekly continuously compounded returns. ***, ** and * denote significance at the 1%, 5%, and 10% levels, respectively.*