Natural disaster and asset price: Evidence from the public commercial real estate market

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Outline

Introduction

- Natural disasters and climate change has significant physical and economic impacts across various sectors in recent decades.
- Physical risk stands out as the primary climate-related risk for corporations and investors, among other potential risks. (Stroebel and Wurgler, 2021)
- Real assets are typically at a higher natural disaster risk due to immobility and il-liquidity characteristics.

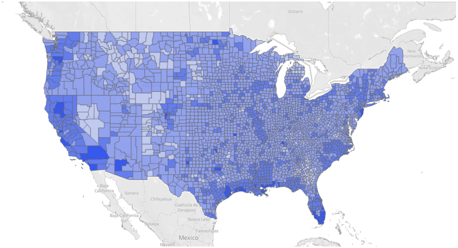

Figure: Cumulative Natural Disaster Damages

Introduction

- Previous literature have tried to investigate the impact of climate change or natural disaster on asset prices.
  - Pricing of climate risk in various financial assets: Huynh and Xia, 2021a, 2021b, Choi, et al., 2020; Kruttli et al., 2021; Goldsmith-Pinkham et al., 2022; Kyung et al., 2022
  - Natural disaster risk and real estate market: Ortega and Taspinar, 2018; Keys and Mulder, 2020; Murfin and Spiegel, 2020; Rehse et al., 2019; Addoum et al., 2021)
- However, measuring the impact of such events on a firm's stock prices was limited.
- This paper uses a novel approach to capture the sensitivity to natural disaster risk using granular property information at firm-level and investigate how it affects firm's stock prices.

Introduction

- Context of REITs (firms holding real assets intensively)
  - REITs are required to allocate at least 75 percent of their assets to real estate.
  - This study investigates whether the stock returns of US REITs reflect the natural disaster risk.
- Natural disaster beta (β^{ND})
  - We estimate a novel natural disaster beta (β^{ND}) measure using property holding information and county-level natural disaster damage data
  - β^{ND} captures the sensitivity of stock returns to time-varying exposure of natural disaster damage across counties where properties of a firm are located.

Introduction

- **Research Question: Does β^{ND} explain excess return in the stock market? If so, why and how it affects the return?**
  - Our finding supports price discount hypothesis
    - β^{ND} has a positive and statistically significant relation with its future stock return
    - An annualized return difference between highest and lowest β^{ND} portfolios is about 4.548 percent.
    - REITs investors (mutual funds investors) dispose REITs holding when a firm has higher β^{ND}.
  - Salience effect, Information accessibility, and governance uncertainty play a role in the stock market associated with natural disaster risk.
    - Investors react less if a firm has experienced several natural disasters in the past.
    - Distant REITs investors (mutual funds investors) dispose REITs holdings when a firm has higher β^{ND}.
    - Pricing of natural disaster risk is greater when the presidential party is Republican.

Main Data

- **Firm-level data: Publicly traded US Equity REITs 1996-2020**
  - COMPUSTAT: annual financial data
  - Center for Research in Security Prices (CRSP): daily and monthly stock prices, market capitalization
  - Firm characteristics: size (SIZE), book-to-market (BM), return on asset (ROA), market beta (β^{MKT}), VIX beta (β^{VIX}), Amihud (2002) illiquidity (ILLIQ), Harvey and Siddique (2002) co-skewness (COSKEW), and Dittmar (2002) co-kurtosis (COKURT)
  - 22,929 observations representing firm-month data points

Main Data

- **Property-level data: REITs portfolio 1996-2020**
  - REITs portfolio data from SNL Global Real Estate Property database
  - CUSIP key, property location, property acquisition year, property disposition year, initial purchase price, and book value
  - Proxy for property values using adjusted cost (Ling, Naranjo, and Scheick, 2018)
  - Counties within the Core-based statistical areas (CBSAs)
  - Exclude the state of Alaska and Hawaii
  - 24,284 properties across 1,472 counties as of 2020

Main Data

- **Natural Disaster Data: Spatial Hazard Events and Losses Database for United States (SHELDUS)**
  - County-month level information of natural disaster
  - FIPs code, Damage volume in dollars, Specific hazard types (e.g., hurricanes, wildfires, earthquake, etc)
  - We exclude flood type natural disasters from our sample (8.67 percent of the sample) because commercial real estate buildings are generally equipped flood insurance.
  - We include meteorological (hurricane, storm, lightning), Climatological (heat, drought), and geophysical disasters (avalanche, landslide)
  - We include events less than 15 days
  - We exclude damages less than $1MM
  - 356,116 county-month observations

Empirical Setting

- **Does a firm's sensitivity to the natural disaster exposure risk explain monthly excess return?**
- β^{ND} Measurement
  - firm-specific time-varying exposure to natural disaster risks

Step 1. Quantify a firm's natural disaster exposure based on property shares

- Property Shares:
  $REShare_{i,c,y} = RE_{i,c,y} / \sum_{C=1}^{N_{c,y}} RE_{i,c,y}$

- Natural Disaster Exposure:
  $NDExposure_{i,t} = \sum_{C=1}^{N_{c,y}} (REShare_{i,c,y} \times NDDamage_{c,t})$

Empirical Setting

Step 2. Estimate β^{ND} using ND exposure and residual returns

- Residual returns:
  $r_{i,t} = \alpha + \beta \Delta VIX_t + \beta MKT_t + \beta SMB_t + \beta HML_t + \beta MOM_t + \epsilon_{i,t}$

- β^{ND}
  $\epsilon_{i,t} = \alpha + \beta^{ND}_{i,t} NDExposure_{i,t} + \epsilon$

Univariate Portfolio Analysis

- Cross-sectional relationship between β^{ND} and future stock returns
- Group firms into five quintile of β^{ND}

	Low	2	3	4	High	High-Low
Raw excess return	0.669	0.684	0.754	1.016	1.048	0.379***
	(2.844)	(2.508)	(2.770)	(3.969)	(3.387)	(3.144)
CAPM alpha	0.069	0.122	0.189	0.483	0.472	0.403***
	(0.226)	(0.363)	(0.593)	(1.759)	(1.325)	(3.318)
FF3 alpha	0.022	0.084	0.153	0.446	0.431	0.409***
	(0.141)	(0.409)	(0.593)	(2.140)	(2.073)	(2.983)
Carhart alpha	0.126	0.155	0.281	0.567	0.500	0.374***
	(1.046)	(0.841)	(1.360)	(3.463)	(2.539)	(2.796)

Dep. variable is time-series average equally weighted one-month-ahead excess returns for each quantile portfolio over the sample period.

Multivariate Portfolio Analysis

Dependent variable: r_{t+1}	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
β^{ND}	0.615***	0.632***	0.618***	0.624***	0.612***	0.555***	0.514***	0.521***	0.533***
	(4.072)	(4.250)	(4.022)	(3.870)	(4.080)	(3.867)	(4.210)	(4.044)	(4.306)
SIZE		0.007	0.049	0.028	0.004	-0.034	-0.005	-0.014	-0.020
		(0.184)	(1.314)	(0.711)	(0.071)	(-0.577)	(-0.074)	(-0.213)	(-0.232)
BM			0.341*	0.289	0.250	0.284*	0.305*	0.302*	0.317*
			(1.815)	(1.611)	(1.545)	(1.766)	(1.685)	(1.773)	(1.891)
ROA				2.991	3.869**	3.123*	2.902	2.901	3.075
				(1.426)	(2.241)	(1.903)	(1.448)	(1.492)	(1.514)
β^{MKT}					0.099	-0.016	-0.126	-0.166	-0.114
					(0.318)	(-0.037)	(-0.314)	(-0.383)	(-0.261)
β^{VIX}						0.021*	0.023**	0.030***	0.031***
						(1.875)	(2.076)	(2.869)	(3.031)
ILLIQ							-0.524	-0.744	-1.367
							(-0.735)	(-0.874)	(-1.128)
COSKEW								-0.454	-1.316
								(-0.749)	(-1.224)
COKURT									-0.125
									(-0.837)
Constant	0.790***	0.729**	0.212	0.267	0.300	0.507*	0.358	0.327	0.266
	(3.271)	(2.161)	(0.693)	(0.890)	(0.916)	(1.696)	(0.955)	(0.887)	(0.678)
R-squared	0.019	0.077	0.100	0.128	0.155	0.179	0.233	0.249	0.265
Observations	22,929	22,929	22,929	22,929	22,929	22,929	22,929	22,929	22,929

Mechanism of β^{ND}: Price Discount Hypothesis

- RMIN (RMAX) is the average 5 days min (max) daily excess return

Dependent variables:	RMIN		RMAX	
	Raw excess returns	Residual returns	Raw excess returns	Residual returns
	(1)	(2)	(3)	(4)
β^{ND}	-0.086***	-0.062**	0.120***	0.078***
	(-3.145)	(-2.538)	(4.080)	(3.076)
SIZE	0.059***	0.079***	-0.071***	-0.091***
	(6.102)	(10.188)	(-6.425)	(-9.072)
BM	0.024	0.080***	0.018	-0.068**
	(0.784)	(3.262)	(0.544)	(-2.182)
ROA	2.982***	2.088***	-3.383***	-2.526***
	(9.319)	(8.989)	(-9.790)	(-8.864)
β^{MKT}	-0.604***	-0.314***	0.611***	0.383***
	(-12.585)	(-8.168)	(12.515)	(8.153)
β^{VIX}	0.026***	0.016***	-0.024***	-0.019***
	(13.046)	(11.062)	(-10.605)	(-9.907)
ILLIQ	-0.710***	-0.785***	0.691***	1.126***
	(-3.989)	(-4.858)	(3.820)	(4.781)
COSKEW	-0.564***	-0.426***	0.474***	0.423***
	(-6.567)	(-6.111)	(5.314)	(4.951)
COKURT	-0.018	0.072***	-0.003	-0.089***
	(-1.084)	(6.651)	(-0.172)	(-6.935)
R-squared	0.483	0.487	0.473	0.500
Observations	22,927	22,927	22,927	22,927

Investor's reaction

- Quarterly mutual fund holding firm data from CRSP Survivorship-Bias free mutual fund database and Thomson Reuters S12 Mutual Fund Holding database.
- Active Change in holdings of all mutual fund investors for firm i

Dependent variables: Active Change	All		Local		Distant	
	Low β_{ND}	High β_{ND}	Low β_{ND}	High β_{ND}	Low β_{ND}	High β_{ND}
	(1)	(2)	(3)	(4)	(5)	(6)
β_{ND}	-0.285	-0.900***	0.037	0.121	-0.224	-1.013***
	(-0.684)	(-3.087)	(0.255)	(1.470)	(-0.593)	(-3.223)
Size	-0.309*	-0.448**	-0.062	-0.003	-0.335*	-0.509**
	(-1.806)	(-2.102)	(-1.025)	(-0.043)	(-1.845)	(-2.202)
BM	-1.023***	-0.326	-0.202**	-0.170*	-0.879***	-0.191
	(-3.705)	(-0.922)	(-2.034)	(-1.820)	(-3.286)	(-0.503)
ROA	-1.770	-4.029	-0.463	-1.172**	-1.401	-4.081
	(-0.562)	(-1.525)	(-0.267)	(-2.365)	(-0.517)	(-1.463)
β^{MKT}	0.077	-0.029	-0.055	-0.043	0.235	0.062
	(0.335)	(-0.118)	(-0.706)	(-0.571)	(0.987)	(0.239)
β^{VIX}	-0.026	-0.006	-0.000	-0.000	-0.025	-0.010
	(-1.647)	(-0.479)	(-0.031)	(-0.024)	(-1.456)	(-0.727)
Illiquid	-0.263	-0.125	-0.112	0.499***	-0.253	-0.193*
	(-1.236)	(-1.295)	(-0.310)	(3.864)	(-1.228)	(-1.774)
Coskew	-0.082	-0.775	0.001	-0.337	-0.745	-0.603
	(-0.105)	(-1.463)	(0.002)	(-1.581)	(-0.746)	(-1.155)
Cokurt	0.080*	-0.016	0.019	0.012	0.066	-0.031
	(1.910)	(-0.274)	(1.372)	(0.525)	(1.570)	(-0.510)
Firm	Y	Y	Y	Y	Y	Y
Year-quarter	Y	Y	Y	Y	Y	Y
R-squared	0.394	0.407	0.287	0.251	0.369	0.385
Observations	3,522	3,593	2,024	2,218	3,517	3,590

Local and Distant Mutual Funds

Dependent variable: r_{t+1}	Distant MF Investor	
	Low	High
	(1)	(2)
β^{ND}	0.178	1.069***
	(0.746)	(3.658)
SIZE	-0.232	0.021
	(-0.996)	(0.247)
BM	0.075	-0.065
	(0.130)	(-0.428)
ROA	2.687	2.891
	(0.884)	(0.670)
β^{MKT}	-0.706	0.330
	(-1.354)	(0.570)
β^{VIX}	0.087**	0.019
	(2.323)	(1.254)
ILLIQ	-7.575	-2.114
	(-0.602)	(-0.443)
COSKEW	-0.187	-0.881
	(-0.123)	(-0.691)
COKURT	0.447	0.033
	(0.598)	(0.100)
Constant	1.453	0.552
	(1.445)	(0.614)
R-squared	0.424	0.417
Observations	10,279	10,727

Salience Effects of Natural Disaster Risk

- The more unexpected natural disaster, more salient effects from investors
- REXP denotes a recent natural disaster within 12 months period

Natural Disaster Types: Dependent Variable: r_{t+1}	All (1)	Meteorological (2)	Climatological (3)	Geophysical (4)
β^{ND}	1.047***	0.904***	0.842***	1.083***
	(3.900)	(3.439)	(3.607)	(4.377)
$\beta^{ND} \times REXP$	-0.952***			
	(-3.151)			
REXP	0.133***			
	(2.706)			
$\beta^{ND} \times REXP^M$		-0.683**		
		(-2.300)		
$REXP^M$		0.122		
		(1.644)		
$\beta^{ND} \times REXP^C$			-0.576**	
			(-2.022)	
$REXP^C$			-0.044	
			(-0.751)	
$\beta^{ND} \times REXP^G$				-1.078***
				(-3.107)
$REXP^G$				-0.002
				(-0.026)
Controls	Yes	Yes	Yes	Yes
R-squared	0.287	0.289	0.290	0.288
Observations	22,929	22,929	22,929	22,929

Partisan Gap: Historical Presidential Parties

Dependent Variable: r_{t+1}	Democratic Era			Republican Era		
	All	Bill Clinton	Barack Obama	All	George W. Bush	Donald Trump
	(1)	(2)	(3)	(4)	(5)	(6)
β^{ND}	0.227*	0.205	0.238	0.809***	0.673***	1.085***
	(1.902)	(0.904)	(1.627)	(3.646)	(2.718)	(4.243)
SIZE	-0.079	0.128	-0.184**	0.040	0.043	0.034
	(-0.905)	(0.738)	(-2.105)	(0.383)	(0.294)	(0.628)
BM	0.487	0.071	0.699	0.127	-0.027	0.442
	(1.402)	(0.431)	(1.358)	(0.452)	(-0.077)	(1.554)
ROA	1.048	3.231**	-0.066	5.224	2.348	11.098***
	(0.804)	(2.067)	(-0.049)	(1.160)	(0.452)	(6.006)
β^{MKT}	0.262	-0.855**	0.832	-0.485	-0.397	-0.665
	(0.518)	(-2.048)	(1.064)	(-1.240)	(-0.797)	(-1.266)
β^{VIX}	0.006	0.024	-0.004	0.056***	0.059*	0.050*
	(0.466)	(0.854)	(-0.161)	(2.904)	(1.823)	(1.752)
ILLIQ	0.084	0.108	0.072	-2.893	-0.121	-8.555
	(0.467)	(0.995)	(0.274)	(-1.191)	(-0.516)	(-1.619)
COSKEW	-1.469**	0.367	-2.406***	-1.115	1.448*	-6.349**
	(-2.556)	(0.633)	(-3.355)	(-0.575)	(1.900)	(-2.307)
COKURT	0.187**	0.199*	0.181*	-0.433**	-0.248	-0.812***
	(2.255)	(1.774)	(1.744)	(-2.385)	(-1.241)	(-4.501)
Constant	-0.011	-0.767	0.375	0.557*	0.622**	0.424
	(-0.013)	(-0.764)	(0.411)	(1.716)	(2.021)	(0.662)
R-squared	0.286	0.211	0.325	0.244	0.246	0.238
Observations	11,170	3,697	7,473	11,759	7,037	4,722

Robustness Check

Dependent Variable: r_{t+1}	Flood included (1)	Flood only (2)	Damage per capita (3)	Nearby ND Damage (4)
β^{ND}	0.301***	-0.003	0.057***	0.125
	(3.017)	(-0.011)	(3.981)	(0.705)
SIZE	-0.022	-0.028	-0.022	-0.010
	(-0.265)	(-0.340)	(-0.260)	(-0.115)
BM	0.312*	0.305*	0.324*	0.314*
	(1.893)	(1.926)	(1.965)	(1.828)
ROA	2.831	2.228	2.742	2.535
	(1.387)	(1.106)	(1.408)	(1.168)
β^{MKT}	-0.150	-0.166	-0.110	-0.123
	(-0.345)	(-0.373)	(-0.240)	(-0.279)
β^{VIX}	0.033***	0.030***	0.031***	0.029***
	(3.056)	(2.869)	(3.022)	(2.689)
ILLIQ	-1.566	-1.071	-1.463	-1.583
	(-1.150)	(-1.120)	(-1.132)	(-1.146)
COSKEW	-1.279	-1.140	-1.253	-1.079
	(-1.140)	(-1.075)	(-1.223)	(-1.030)
COKURT	-0.102	-0.081	-0.075	-0.112
	(-0.674)	(-0.551)	(-0.527)	(-0.737)
Controls	Yes	Yes	Yes	Yes
R-squared	0.264	0.265	0.263	0.264
Observations	22,929	22,929	22,929	22,929

Conclusion

- We find a positive relationship between β^{ND} and excess return.
- REITs investors sell off REITs holdings when β^{ND} is higher. This changes are primarily driven by distant investors.
- Salience effect plays a role in the stock market. β^{ND} has a greater relationship with excess return when a firm is less exposed to natural disaster risks recently.
- If investors feel uncertainty from the governance (presidential political party), they require even higher returns from firms with higher β^{ND}.

Appendix

APPENDIX

Summary Statistics of Natural Disaster Damage

Panel A. 1996 to 2000	N	Mean	SD	P25	P50	P75
Total damage	23,149	1,758.08	23,613.47	4.18	18.88	83.53
Meteorological	19,572	1,544.17	16,403.55	4.02	15.73	67.60
Climatological	4,334	1,943.73	37,972.46	12.11	34.53	210.29
Geophysical	86	23,851.04	126,131.35	7.87	132.41	8,054.50
Panel B. 2001 to 2010	N	Mean	SD	P25	P50	P75
Total damage	44,612	3,814.17	106,833.85	3.64	14.80	73.31
Meteorological	43,770	3,590.21	106,432.29	3.64	14.57	71.23
Climatological	602	12,291.41	90,610.91	34.19	182.62	1,300.20
Geophysical	571	9,832.64	119,956.06	1.97	15.27	120.21
Panel C. 2011 to 2020	N	Mean	SD	P25	P50	P75
Total damage	41,068	3,849.13	118,003.88	2.50	10.11	46.24
Meteorological	40,018	3,167.05	106,963.15	2.50	9.90	41.75
Climatological	911	31,002.17	350,907.86	7.88	98.45	996.50
Geophysical	557	5,555.12	44,304.46	0.12	10.47	409.79

Summary Statistics of Property Holding Information

Year	REIT N	Property N	County N	Total Value ($ million)	Mean Value ($ million)
1996	130	7,020	913	80,292.61	11.44
1997	140	10,454	985	142,795.30	13.66
1998	149	14,615	1,057	222,935.10	15.25
1999	148	16,376	1,104	252,573.50	15.42
2000	144	16,315	1,080	260,668.80	15.98
2001	144	16,028	1,078	270,957.10	16.91
2002	140	15,729	1,060	303,237.10	19.28
2003	146	15,814	1,058	323,380.60	20.45
2004	152	17,325	1,101	366,485.80	21.15
2005	149	18,103	1,196	386,127.00	21.33
2006	128	15,955	1,127	387,748.20	24.30
2007	115	15,699	1,116	410,922.10	26.18
2008	117	15,087	1,057	440,194.80	29.18
2009	124	15,117	1,057	451,448.70	29.86
2010	135	16,240	1,113	483,038.80	29.74
2011	147	18,138	1,230	536,745.10	29.59
2012	152	18,345	1,251	565,150.60	30.81
2013	166	21,141	1,397	655,446.60	31.00
2014	177	25,285	1,508	730,893.50	28.91
2015	170	25,283	1,505	759,758.30	30.05
2016	174	25,161	1,495	811,605.60	32.26
2017	169	25,793	1,493	860,363.90	33.36
2018	163	25,330	1,492	877,507.00	34.64
2019	159	23,946	1,457	910,015.30	38.00
2020	158	24,284	1,472	920,964.10	37.92
Total	147	18,343	1,216	496,450.22	25.47