Measuring the impact of natural disasters on capital markets: an empirical application using intervention analysis

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Tables:

Table 1. *Summary statistics of price and accumulation returns*
Notes: This table provides measures of central tendency, dispersion and shape for the daily price and accumulation returns on the All Ordinaries Index (AOI). The sample period is from 31 December 1982–1 January 2002. The critical values of significance for skewness and kurtosis at the 0.05 level are 0.0681 and 0.1363, respectively, JB – Jarque–Bera. Augmented Dickey–Fuller (ADF) tests hypotheses are H_0: unit root, H_1: no unit root (stationary). The lag orders in the ADF equations are determined by the significance of the coefficient for the lagged terms. Optimal lag is six for both price and accumulation returns. Kwiatkowski, Phillips, Schmidt and Shin (KPSS) unit root test hypotheses are H_0: no unit root (stationary), H_1: unit root.

	Price	Accumulation
Observations	4958	4958
Mean	0.0004	0.0005
Standard deviation	0.0097	0.0097
Maximum	0.0607	0.0622
Minimum	−0.2876	−0.2875
Skewness	−5.9520	−5.9125
Kurtosis	166.5038	165.7662
Jarque–Bera statistic	5551967	5501866
JP *p*-value	0.0000	0.0000
ADF statistic Constant only	−24.0250	−24.0939
Constant and trend	−24.0544	−24.1262
Critical value 0.10 level	−2.5670	−2.5670
Critical value 0.05 level	−2.8619	−2.8619

Critical value 0.01 level	−3.4315	−3.4315
KPSS statistic Constant only	0.1657	0.1731
Constant and trend	0.0567	0.0530
Critical value 0.10 level	0.3470	0.3470
Critical value 0.05 level	0.4630	0.4630
Critical value 0.01 level	0.7390	0.7390

Table 2. *Australian natural disasters by date, 1983–2002*

		Persons killed		Insured loss		Total loss		Insured to total loss	
Event category	**Event date**	**No.**	**Rank**	**Value**	**Rank**	**Value**	**Rank**	**%**	**Rank**

		Persons killed		Insured loss		Total loss		Insured to total loss	
Event category	Event date	No.	Rank	Value	Rank	Value	Rank	%	Rank
Bushfire	16 Feb 83	75	1	324	4	960	3	34	14
Flood	12 Nov 94	0	30	132	8	550	6	24	26
Bushfire	14 Jan 85	5	9	6	41	100	38	6	40
Storm	18 Jan 85	1	18	299	5	420	7	71	2
Cyclone	1 Feb 86	3	12	65	15	300	11	22	28
Flood	5 Aug 86	6	6	53	18	270	14	20	30
Storm	3 Oct 86	0	30	161	7	255	15	63	5
Flood	24 Apr 88	0	30	36	29	230	17	16	34
Cyclone	4 Apr 89	1	18	35	31	175	23	20	29
Earthquake	28 Dec 89	13	3	1124	2	4500	1	25	25
Cyclone	3 Feb 90	6	6	42	21	230	17	18	31
Storm	18 Mar 90	0	30	384	3	560	5	69	3
Flood	21 Apr 90	7	4	38	25	410	8	9	38
Cyclone	23 Dec 90	6	6	62	16	385	10	16	33
Storm	21 Jan 91	1	18	226	6	670	4	34	15
Flood	16 Dec 91	0	30	24	36	105	37	23	27
Storm	12 Feb 92	0	30	118	9	220	19	54	6
Flood	3 Oct 93	1	18	12	38	400	9	3	41
Bushfire	29 Dec 93	4	11	58	17	175	23	33	19
Cyclone	23 May 94	2	15	37	26	115	33	32	21

		Persons killed		Insured loss		Total loss		Insured to total loss	
Event category	Event date	No.	Rank	Value	Rank	Value	Rank	%	Rank
Storm	25 May 94	0	30	37	26	135	27	27	23
Earthquake	6 Aug 94	0	30	36	29	140	26	26	24
Cyclone	23 Feb 95	7	4	11	39	100	38	11	36
Storm	5 Nov 95	1	18	40	22	110	35	36	10
Flood	1 May 96	5	9	31	34	240	16	13	35
Storm	29 Sep 96	0	30	104	10	300	11	35	13
Flood	15 Nov 96	1	18	20	37	120	30	17	32
Storm	11 Dec 96	1	18	50	19	150	25	33	17
Earthquake	30 Jul 97	18	2	11	39	100	38	11	36
Storm	19 Dec 97	1	18	40	22	100	38	40	7
Flood	10 Jan 98	2	15	69	14	210	20	33	20
Flood	26 Jan 98	3	12	70	13	200	22	35	11
Flood	17 Aug 98	1	18	50	19	130	28	38	8
Storm	16 Dec 98	0	30	76	12	115	33	66	4
Cyclone	22 Mar 99	0	30	35	31	120	30	29	22
Storm	14 Apr 99	1	18	1700	1	2300	2	74	1
Storm	24 Oct 99	1	18	35	31	100	38	35	11
Flood	6 Mar 01	1	18	25	35	300	11	8	39
Storm	9 Mar 01	0	30	37	26	110	35	34	16
Storm	18 Nov 01	3	12	40	22	120	30	33	17

		Persons killed		Insured loss		Total loss		Insured to total loss	
Event category	Event date	No.	Rank	Value	Rank	Value	Rank	%	Rank
Storm	3 Dec 01	2	15	3	42	130	28	2	42
Bushfire	12 Dec 01	0	30	80	11	210	20	38	9

Notes: This table details all natural events, disasters and catastrophes occurring in Australia over the period 1983–2002 satisfying the size criteria. The conditions set for inclusion is A$5 mil. insured loss and/or A$100 total loss. The dates given are actual dates when substantial loss was first known. Disaster categories are: (i) bushfires (wildfires), (ii) tropical cyclones (including tornados and sea spouts), (iii) earthquakes (including landslides), (iv) severe storms (including hail) and (v) floods (including flash floods). Ranks in descending order. Insured loss to total loss is the ratio of insured losses to estimated total losses. *Source*: Emergency Management Australia (EMA, 2003).

Table 3. *Estimated equations for price and accumulation returns*

	Price returns–full specification			Price returns–refined specification			Accumulation returns–full specification			Accumulation returns–refined specification		
	Coefficient	Std. error	*p*-value	Coefficient	Std. error	*p*-value	Coefficient	Std. error	*p*-value	Coefficient	Std. error	*p*-value
μ_0	0.0006	0.0001	0.0001	0.0006	0.0001	0.0000	0.0007	0.0001	0.0000	0.0007	0.0001	0.0000
γ_1	−0.2821	0.0035	0.0000	−0.2821	0.0034	0.0000	−0.2835	0.0028	0.0000	−0.2834	0.0025	0.0000
γ_2	−0.0616	0.0081	0.0000	−0.0616	0.0080	0.0000	−0.0540	0.0097	0.0000	−0.0540	0.0097	0.0000
β_{10}	0.0085	0.0027	0.0015	0.0086	0.0027	0.0013	0.0087	0.0026	0.0009	0.0079	0.0027	0.0039
β_{11}	0.0055	0.0019	0.0043	0.0054	0.0020	0.0055	0.0051	0.0020	0.0100	0.0051	0.0019	0.0076
β_{12}	−0.0006	0.0029	0.8421	–	–	–	−0.0007	0.0030	0.8267	–	–	–

	Price returns–full specification			Price returns–refined specification			Accumulation returns–full specification			Accumulation returns–refined specification		
	Coefficient	**Std. error**	***p*-value**	**Coefficient**	**Std. error**	***p*-value**	**Coefficient**	**Std. error**	***p*-value**	**Coefficient**	**Std. error**	***p*-value**
β_{13}	−0.0047	0.0061	0.4399	–	–	–	−0.0049	0.0059	0.4056	–	–	–
β_{14}	0.0042	0.0019	0.0239	0.0052	0.0019	0.0054	0.0045	0.0019	0.0165	0.0044	0.0018	0.0148
β_{15}	−0.0003	0.0048	0.9541	–	–	–	−0.0006	0.0048	0.9070	–	–	–
β_{20}	−0.0008	0.0023	0.7362	–	–	–	−0.0005	0.0024	0.8397	–	–	–
β_{21}	0.0015	0.0014	0.2882	–	–	–	0.0013	0.0014	0.3717	–	–	–
β_{22}	−0.0095	0.0022	0.0000	−0.0098	0.0022	0.0000	−0.0093	0.0022	0.0000	−0.0097	0.0022	0.0000
β_{23}	0.0028	0.0027	0.3011	–	–	–	0.0029	0.0027	0.2741	–	–	–
β_{24}	−0.0009	0.0019	0.6406	–	–	–	−0.0008	0.0019	0.6699	–	–	–
β_{25}	−0.0026	0.0012	0.0326	−0.0025	0.0012	0.0368	−0.0026	0.0013	0.0383	−0.0025	0.0012	0.0359
β_{30}	−0.0043	0.0009	0.0000	−0.0047	0.0010	0.0000	−0.0035	0.0015	0.0205	−0.0038	0.0015	0.0121
β_{31}	0.0010	0.0010	0.3158	–	–	–	0.0012	0.0011	0.2496	–	–	–
β_{32}	−0.0033	0.0021	0.1198	–	–	–	−0.0034	0.0020	0.0906	–	–	–
β_{33}	−0.0025	0.0032	0.4340	–	–	–	−0.0027	0.0032	0.3945	–	–	–
β_{34}	0.0064	0.0080	0.4259	–	–	–	0.0063	0.0079	0.4239	–	–	–
β_{35}	0.0067	0.0030	0.0251	0.0059	0.0028	0.0379	0.0068	0.0030	0.0227	0.0060	0.0028	0.0327
β_{40}	0.0014	0.0015	0.3572	–	–	–	0.0015	0.0017	0.3690	–	–	–
β_{41}	−0.0002	0.0019	0.9084	–	–	–	−0.0002	0.0017	0.9071	–	–	–
β_{42}	−0.0007	0.0019	0.7078	–	–	–	0.0014	0.0023	0.5524	–	–	–

	Price returns–full specification			Price returns–refined specification			Accumulation returns–full specification			Accumulation returns–refined specification		
	Coefficient	**Std. error**	***p*-value**	**Coefficient**	**Std. error**	***p*-value**	**Coefficient**	**Std. error**	***p*-value**	**Coefficient**	**Std. error**	***p*-value**
β_{43}	0.0000	0.0014	0.9983	–	–	–	−0.0002	0.0015	0.9039	–	–	–
β_{44}	0.0011	0.0020	0.5751	–	–	–	0.0009	0.0020	0.6299	–	–	–
β_{45}	0.0018	0.0016	0.2574	–	–	–	0.0007	0.0012	0.5808	–	–	–
β_{50}	−0.0011	0.0021	0.5835	–	–	–	−0.0023	0.0021	0.2749	–	–	–
β_{51}	0.0010	0.0023	0.6612	–	–	–	0.0025	0.0020	0.2206	–	–	–
β_{52}	0.0006	0.0028	0.8388	–	–	–	0.0019	0.0029	0.5116	–	–	–
β_{53}	0.0002	0.0021	0.9167	–	–	–	0.0002	0.0016	0.8840	–	–	–
β_{54}	−0.0029	0.0021	0.1639	–	–	–	0.0003	0.0015	0.8313	–	–	–
β_{55}	−0.0035	0.0025	0.1571	–	–	–	−0.0030	0.0023	0.2042	–	–	–
ρ_1	0.3184	0.0507	0.0000	0.3144	0.0502	0.0000	0.3137	0.0575	0.0000	0.3161	0.0444	0.0000
ρ_2	−0.9273	0.0365	0.0000	−0.9285	0.0356	0.0000	−0.9246	0.0418	0.0000	−0.9587	0.0313	0.0000
ρ_3	0.1232	0.0222	0.0000	0.1229	0.0221	0.0000	0.1086	0.0239	0.0000	0.1122	0.0228	0.0000
ϕ	0.0326	0.0184	0.0766	0.0323	0.0183	0.0771	0.0283	0.0181	0.1008	−	−	-
θ_1	−0.2017	0.0458	0.0000	−0.1975	0.0452	0.0000	0.8723	0.0467	0.0000	0.9138	0.0364	0.0000
θ_2	0.8728	0.0413	0.0000	0.8747	0.0405	0.0000	−0.2064	0.0522	0.0001	−0.2089	0.0380	0.0000
Adj. R^2	0.274	–	–	0.276	–	–	0.261	–	–	0.261	–	–
DW	2.00	–	–	2.00	–	–	2.00	–	–	1.99	–	–
SC	−6.70	–	–	−6.74	–	–	−6.68	–	–	−6.72	–	–

	Price returns–full specification			Price returns–refined specification			Accumulation returns–full specification			Accumulation returns–refined specification		
	Coefficient	Std. error	*p*-value	Coefficient	Std. error	*p*-value	Coefficient	Std. error	*p*-value	Coefficient	Std. error	*p*-value
Q(*l*=36)	25.841	–	0.6830	26.801	–	0.6340	27.064	–	0.6200	30.871	–	0.4730
LM(*l*=5)	0.7864	–	0.5593	0.7937	–	0.5540	0.9385	–	0.4546	1.3141	–	0.2548
LM(*l*=10)	0.6501	–	0.7715	0.6349	–	0.7850	0.7489	–	0.6786	1.0768	–	0.3762
LM(*l*=15)	0.8394	–	0.6339	0.8597	–	0.6103	0.7733	–	0.7089	1.2045	–	0.2596

Notes: Dependent variables are price and accumulation returns for a full and refined specification, μ_0 is the equation constant; γ_1 and γ_2 are the estimated coefficients for the macroeconomic incident equation terms, disaster equation terms are denoted β_{ij}, where i=1 (bushfires), 2 (cyclones), 3 (earthquakes), 4 (storms), 5 (floods) and the number of lags (in days) is j=0, 1, 2, 3, 4, 5, ρ_1 ρ_2 and ρ_3 are autoregressive terms, ϕ is the seasonal lag term (r=10 for price returns and r=11 for accumulation returns), θ_1 and θ_2 are moving average terms, DW – Durbin–Watson statistic, Schwartz Criterion, Q(l) is the Ljung–Box Q-statistic where l is the number of lags in days, LM(l) is the Breusch–Godfrey Lagrange multiplier statistic where l is the number of lags in days

Table 4. *Correlogram of residuals for the estimated intervention models*

	Price returns–refined specification				Accumulation returns– refined specification			
l	AC	PAC	*Q*-statistic	*p*-value	AC	PAC	*Q*-statistic	*p*-value
1	0.0020	0.0020	0.0262	–	0.0030	0.0030	0.0408	–
2	−0.0180	−0.0180	1.6504	–	−0.0270	−0.0270	3.7368	–
3	0.0130	0.0130	2.4632	–	0.0160	0.0160	4.9525	–
4	−0.0140	−0.0150	3.4655	–	−0.0030	−0.0040	5.0007	–
5	−0.0010	0.0000	3.4683	–	−0.0030	−0.0020	5.0376	–

	Price returns–refined specification				Accumulation returns– refined specification			
l	AC	PAC	*Q*-statistic	*p*-value	AC	PAC	*Q*-statistic	*p*-value
6	−0.0050	−0.0060	3.6010	–	−0.0070	−0.0080	5.2935	0.0580
7	−0.0010	0.0000	3.6045	0.0580	−0.0070	−0.0070	5.5411	0.0630
8	−0.0090	−0.0100	4.0370	0.1330	−0.0040	−0.0040	5.6173	0.1320
9	0.0140	0.0140	5.0101	0.1710	0.0070	0.0070	5.8827	0.2080
10	0.0000	−0.0010	5.0110	0.2860	0.0230	0.0230	8.4919	0.1310
11	0.0200	0.0200	6.9267	0.2260	0.0270	0.0270	12.0160	0.0620
12	0.0190	0.0180	8.7480	0.1880	0.0240	0.0240	14.7600	0.0390
13	0.0080	0.0100	9.1005	0.2460	−0.0020	−0.0020	14.7830	0.0640
14	0.0110	0.0110	9.7170	0.2850	0.0070	0.0080	15.0600	0.0890
15	0.0000	0.0000	9.7178	0.3740	0.0050	0.0040	15.1730	0.1260
16	−0.0190	−0.0190	11.5780	0.3140	−0.0190	−0.0180	16.8960	0.1110
17	−0.0040	−0.0040	11.6620	0.3900	0.0000	0.0010	16.8960	0.1540
18	−0.0060	−0.0070	11.8700	0.4560	−0.0170	−0.0170	18.3460	0.1450
19	0.0040	0.0050	11.9430	0.5320	0.0070	0.0080	18.6080	0.1800
20	0.0130	0.0130	12.8370	0.5390	0.0090	0.0070	18.9860	0.2140
21	−0.0270	−0.0280	16.5800	0.3450	−0.0240	−0.0250	21.8220	0.1490
22	−0.0030	−0.0030	16.6180	0.4110	0.0070	0.0060	22.0860	0.1810
23	0.0110	0.0090	17.2620	0.4370	0.0070	0.0040	22.3290	0.2180
24	−0.0080	−0.0080	17.5620	0.4850	−0.0070	−0.0080	22.6040	0.2550
25	0.0020	0.0020	17.5900	0.5500	−0.0040	−0.0050	22.6910	0.3040

	Price returns–refined specification				Accumulation returns– refined specification			
l	AC	PAC	*Q*-statistic	*p*-value	AC	PAC	*Q*-statistic	*p*-value
26	−0.0070	−0.0080	17.8500	0.5970	−0.0060	−0.0070	22.8970	0.3490
27	−0.0120	−0.0110	18.5360	0.6150	−0.0090	−0.0080	23.2980	0.3850
28	−0.0110	−0.0110	19.1410	0.6370	−0.0080	−0.0070	23.6020	0.4260
29	−0.0110	−0.0110	19.7110	0.6590	−0.0170	−0.0170	24.9630	0.4080
30	−0.0060	−0.0060	19.9180	0.7010	−0.0090	−0.0080	25.3480	0.4430
31	0.0050	0.0040	20.0330	0.7450	0.0010	0.0000	25.3510	0.4990
32	−0.0340	−0.0350	25.9150	0.4680	−0.0290	−0.0290	29.5380	0.3350
33	0.0060	0.0070	26.1080	0.5130	0.0120	0.0130	30.2720	0.3500
34	0.0080	0.0050	26.4000	0.5510	0.0000	−0.0030	30.2730	0.4000
35	−0.0060	−0.0040	26.5750	0.5950	−0.0070	−0.0050	30.5340	0.4390
36	−0.0070	−0.0070	26.8010	0.6340	−0.0080	−0.0080	30.8710	0.4730

Notes: This table presents the AC – autocorrelation and PAC – partial autocorrelation functions for the refined models in Table 3 for 36 lagged periods. The final models are ARMA(3, 2) for price returns and ARMA(3, 2) for accumulation returns. $Q(l)$ is the Ljung–Box statistic where l is the number of lags in days

Table 5. Joint hypothesis tests for estimated disaster coefficients

Type	Hypothesis		*F*-statistic	*p*-value
Price returns				
Bushfires	$\beta_{1j}=0$	j=0,1,2,3,4,5	3.7214	0.0011

Type	Hypothesis		*F*-statistic	*p*-value
Cyclones	$\beta_{2j}=0$	j=0,1,2,3,4,5	4.4860	0.0002
Earthquakes	$\beta_{3j}=0$	j=0,1,2,3,4,5	5.6769	0.0000
Storms	$\beta_{4j}=0$	j=0,1,2,3,4,5	0.4101	0.8728
Floods	$\beta_{5j}=0$	j=0,1,2,3,4,5	0.7045	0.6460
Bushfires	$\beta_{1j}=0$	j=2,3,5	0.2087	0.8904
Cyclones	$\beta_{2j}=0$	j=0,1,3,4	0.7378	0.5661
Earthquakes	$\beta_{3j}=0$	j=1,2,3,4	1.1740	0.3201
Accumulation returns				
Bushfires	$\beta_{1j}=0$	j=0,1,2,3,4,5	3.8351	0.0008
Cyclones	$\beta_{2j}=0$	j=0,1,2,3,4,5	4.2505	0.0003
Earthquakes	$\beta_{3j}=0$	j=0,1,2,3,4,5	2.8014	0.0101
Storms	$\beta_{4j}=0$	j=0,1,2,3,4,5	0.2917	0.9412
Floods	$\beta_{5j}=0$	j=0,1,2,3,4,5	0.8603	0.5233
Bushfires	$\beta_{1j}=0$	j=2,3,5	0.2245	0.8643
Cyclones	$\beta_{2j}=0$	j=0,1,3,4	0.6271	0.6431
Earthquakes	$\beta_{3j}=0$	j=1,2,3,4	1.3908	0.2344

Notes: This table presents joint hypothesis tests for the estimated disaster coefficients in Table 4. The first set of tests for price and accumulation returns are drawn from the full specification and the second set in each instance is from the refined specification. Estimated disaster coefficients βij, where i=1 (bushfires), 2 (cyclones), 3 (earthquakes), 4 (storms), 5 (floods) and the number of lags (in days) is j=0, 1, 2, 3, 4, 5.