

Business Time Sampling Scheme with Applications to Testing Semi-martingale Hypothesis and Estimating Integrated Volatility

Yingjie Dong

Business School, University of International Business and Economics, Beijing

Yiu-Kuen Tse

School of Economics, Singapore Management University

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Supplemental Appendix

1 Intraday Periodicity and the BTS Scheme

We examine the intraday periodicity in volatility and trading activity of the top 40 stocks (by market capitalization as of 2010) from the NYSE from January 2010 to April 2013. We calculate the squared 1-min calendar-time returns on each trading day and take the average at each 1-min time interval over all trading days in the sample period. These series are treated as 1-min intraday realized volatility estimates, which are plotted on the left-hand column of Figure A.1 (realized volatility is reported in annualized standard deviation in percent). We also calculate the total number of transactions at each sec from 09:30 to 16:00 over all trading days, which are plotted on the right-hand column of Figure A.1. The intraday periodicity in volatility are quite different from that in trading activity, which shows that we cannot use the TTS scheme to approximate the BTS scheme.

In Table A.1 we report the proportion of detected jumps at different sampling frequencies under different sampling schemes using the sequential jump-detection procedure of Andersen et al. (2010). We investigate cases when the sampling frequency is equal to 1 min, 5 min or 10 min. We also calculate the proportion of trading days for which we reject the normality assumption at the 5% significance level for the CTS, TTS and BTS returns at different sampling frequencies with jump adjustment. Table A.2 presents the results for the returns with jumps deleted using the sequential method of Andersen et al. (2010) at the significance level of 1%. Table A.3 reports the results for the returns without jump adjustment.

2 Simulation Results for the Integrated Volatility Estimates

Tables A.4-A.9 provide the mean error (ME) and root mean-squared error (RMSE) of the daily integrated volatility estimates using the TRV method with and without subsampling under different sampling schemes. Table A.9 is the same as Table 4 of the paper. Tables A.10-A.12 report the ME and RMSE of the RK and the ACD-ICV estimates for MD2, MD3 and MD4.

Table S1: Proportion of detected jumps

Stock	1-min			5-min			10-min		
	CTS	TTS	BTS	CTS	TTS	BTS	CTS	TTS	BTS
XOM	4.70	2.55	1.91	4.67	3.90	2.77	7.36	5.84	4.73
WMT	18.10	8.79	7.35	5.78	3.81	4.38	8.16	5.87	5.36
GE	20.54	21.15	26.07	10.58	8.41	5.95	10.82	8.23	6.42
CVX	3.49	1.68	1.93	4.41	3.13	3.07	6.64	5.94	4.86
IBM	5.99	1.80	2.71	4.66	3.46	3.75	6.51	5.42	4.62
JNJ	16.62	9.88	4.78	5.55	4.57	4.00	7.59	6.42	5.41
T	21.87	20.54	25.55	9.13	7.68	5.12	9.77	6.82	6.60
PG	17.33	9.33	4.99	5.82	4.54	4.18	7.95	6.06	5.33
JPM	8.50	3.66	3.57	4.92	3.23	3.22	7.50	5.33	4.70
WFC	17.96	10.43	6.87	6.06	4.65	3.47	7.68	5.61	4.73
KO	17.93	11.03	7.46	6.70	4.21	4.18	7.79	6.06	5.46
PFE	19.62	20.48	26.02	12.96	11.13	9.28	10.02	9.09	6.90
C	8.50	6.15	7.96	8.92	8.60	8.44	10.56	10.05	8.60
BAC	21.83	22.43	22.01	12.91	11.50	12.97	12.59	8.41	6.82
SLB	2.75	1.44	1.91	4.59	3.27	3.13	6.68	5.66	4.41
MRK	22.29	15.45	11.96	6.44	5.44	4.24	8.50	6.17	5.78
PEP	18.00	8.97	5.72	6.15	4.71	4.07	7.03	5.98	5.19
VZ	23.07	17.65	17.31	7.50	5.90	4.86	8.64	6.97	5.80
COP	8.27	4.38	2.83	5.04	3.46	3.26	7.32	5.21	4.40
GS	6.50	1.49	2.86	4.93	3.81	3.34	7.56	5.76	5.05
MCD	10.11	3.94	4.07	5.13	3.80	3.89	7.17	5.89	5.00
OXY	5.93	1.92	2.58	4.78	3.78	3.29	6.94	5.52	4.30
ABT	19.87	12.64	8.45	5.97	4.62	4.05	7.78	6.21	5.68
UTX	10.33	3.12	3.39	5.44	3.41	3.48	7.57	5.23	5.46
UPS	12.64	3.64	3.41	5.35	4.34	3.79	6.63	5.73	5.02
F	19.73	20.02	27.25	13.73	10.46	7.08	11.92	8.82	6.80
DIS	17.89	9.75	7.61	5.19	4.44	4.51	7.62	6.15	5.57
MMM	9.17	2.66	2.89	4.99	3.68	3.50	7.39	6.45	5.06
CAT	3.62	1.65	2.25	4.74	3.40	3.43	6.79	5.06	4.35
FCX	5.90	2.46	2.63	4.21	2.94	2.99	6.62	5.29	4.55
USB	21.82	15.96	13.08	7.95	4.96	4.32	8.39	5.83	4.89
MO	20.09	20.12	26.06	11.25	9.36	7.33	10.90	7.76	7.14
AXP	12.20	4.24	3.61	4.45	3.55	3.39	7.90	5.30	4.33
BA	10.05	2.72	3.14	4.59	4.24	3.54	7.64	6.03	5.12
MDT	23.52	12.86	10.32	6.67	5.25	4.10	7.60	6.23	5.87
HD	17.39	9.08	8.20	5.40	4.59	4.78	7.58	5.99	5.72
CVS	24.02	13.18	12.58	6.64	4.29	5.09	7.47	6.38	6.26
EMC	22.96	18.22	20.48	7.57	6.19	4.86	8.81	6.60	5.62
HAL	8.03	2.78	3.41	4.66	3.75	3.30	6.73	5.96	5.00
PNC	13.63	3.21	3.14	5.28	3.64	3.34	7.43	5.40	5.23

Notes: The figures in the table are the proportions of detected jumps in percentage (2010-2013).

Table S2: Rejection proportion of the normality hypothesis for no-jump returns under different sampling schemes

Stock	1-min			5-min			10-min		
	CTS	TTS	BTS	CTS	TTS	BTS	CTS	TTS	BTS
XOM	93.86	86.04	81.95	18.41	12.64	8.06	7.46	6.14	4.57
WMT	99.76	99.76	98.44	43.08	25.27	17.45	13.36	7.34	5.90
GE	100.00	100.00	99.88	82.55	72.80	67.51	35.42	29.72	21.18
CVX	89.33	78.19	68.23	13.36	7.62	5.86	6.46	5.86	3.52
IBM	83.49	76.39	41.93	13.25	12.65	4.82	7.95	4.34	5.42
JNJ	99.40	98.80	97.11	39.16	29.28	15.66	14.10	8.55	6.39
T	100.00	100.00	99.88	75.93	67.39	53.31	30.45	24.19	17.81
PG	100.00	98.80	97.11	36.58	25.27	14.92	11.43	8.67	5.54
JPM	99.04	95.43	92.18	27.08	16.61	8.42	10.35	6.74	6.14
WFC	99.88	99.18	97.54	45.02	31.18	21.57	15.24	10.43	6.57
KO	99.53	98.48	97.30	42.32	32.59	18.05	13.83	9.50	7.62
PFE	100.00	100.00	100.00	87.22	82.65	71.51	39.39	35.52	26.73
C	99.65	97.89	94.61	57.21	47.71	45.37	46.89	42.56	39.79
BAC	100.00	100.00	99.88	83.35	77.37	69.75	47.48	37.63	30.25
SLB	85.09	75.70	48.71	15.73	11.03	5.52	6.81	5.99	3.17
MRK	100.00	99.65	98.94	55.10	48.30	30.13	18.52	13.48	10.32
PEP	99.53	98.36	96.72	37.98	29.43	13.13	11.72	9.73	3.87
VZ	100.00	100.00	99.88	60.96	50.06	32.24	23.21	17.35	10.67
COP	96.13	91.91	84.64	22.30	16.65	12.19	9.61	6.57	4.57
GS	82.53	68.00	24.15	13.60	11.96	4.92	7.98	5.74	2.70
MCD	98.59	95.90	92.73	27.67	20.16	9.38	11.37	9.50	5.75
OXY	85.93	83.70	51.35	15.36	13.72	5.74	8.09	6.45	4.22
ABT	99.77	99.41	98.71	47.13	36.34	21.22	16.30	13.95	6.57
UTX	97.30	94.49	84.41	25.56	20.28	7.27	11.61	8.80	5.16
UPS	97.66	95.08	90.04	24.03	19.58	8.21	12.19	9.26	3.40
F	100.00	100.00	100.00	87.22	78.90	73.97	43.85	34.11	27.67
DIS	99.77	99.53	98.59	41.85	30.13	18.52	13.13	8.91	7.39
MMM	96.48	91.44	79.72	21.57	15.94	7.15	6.69	7.85	4.69
CAT	89.21	75.73	49.71	17.00	10.67	5.04	6.92	6.21	3.05
FCX	89.33	74.44	59.55	16.30	10.90	7.62	8.80	5.16	4.81
USB	100.00	99.77	99.41	55.69	45.13	29.66	20.87	14.07	9.14
MO	100.00	100.00	99.88	86.64	77.96	64.13	39.39	30.60	23.24
AXP	98.71	96.37	92.26	25.21	18.76	11.84	10.08	6.68	5.04
BA	97.77	93.67	81.83	26.73	20.28	6.10	12.78	9.15	3.52
MDT	100.00	100.00	98.94	48.71	36.74	19.72	15.75	12.56	6.92
HD	100.00	99.65	98.36	41.15	32.24	18.29	13.83	10.67	7.16
CVS	99.88	99.53	99.06	49.41	35.33	18.78	13.73	12.09	8.22
EMC	100.00	100.00	99.77	65.65	54.40	35.29	22.51	18.41	9.96
HAL	96.37	92.03	85.58	22.51	14.42	8.44	8.56	6.21	3.63
PNC	98.12	93.20	83.24	24.74	17.82	6.45	9.73	8.22	5.75

Notes: The normality test is implemented for the high-frequency returns (2010-2013) without jumps and the significance level is 5%. The figures are in percentage of proportion of the trading days that reject the normality hypothesis. Total number of trading days of each stock investigated in our paper ranges from 830 to 853.

Table S3: Rejection proportion of the normality hypothesis for returns under different sampling schemes

Stock	1-min			5-min			10-min		
	CTS	TTS	BTS	CTS	TTS	BTS	CTS	TTS	BTS
XOM	94.22	86.76	81.35	19.37	13.48	10.35	7.58	7.82	5.05
WMT	99.76	99.64	98.19	41.16	25.99	20.34	13.24	8.78	6.26
GE	100.00	100.00	99.88	81.95	73.16	68.83	34.54	28.52	22.86
CVX	88.86	76.79	68.93	15.24	8.21	7.62	7.74	6.80	4.69
IBM	85.54	77.59	43.01	14.34	13.01	7.23	9.04	4.70	6.14
JNJ	99.64	98.80	97.11	35.66	29.52	18.19	15.18	9.88	7.23
T	100.00	100.00	99.88	75.69	67.51	53.91	31.17	24.79	17.21
PG	100.00	98.68	96.99	36.46	25.27	16.49	12.64	10.47	7.22
JPM	99.04	95.67	92.78	27.20	17.45	9.99	11.31	7.22	6.86
WFC	99.88	99.30	97.30	43.26	32.36	23.56	14.54	11.84	8.21
KO	99.30	98.48	97.30	42.91	32.12	20.28	15.01	9.96	9.61
PFE	100.00	100.00	100.00	85.93	81.48	72.10	39.16	35.05	27.67
C	99.65	97.89	94.61	57.91	47.36	46.66	47.01	43.26	40.33
BAC	100.00	100.00	99.88	83.35	77.61	70.11	47.13	36.46	31.77
SLB	84.51	74.77	49.88	14.91	11.85	6.22	8.22	6.10	4.23
MRK	100.00	99.65	98.83	54.87	48.30	31.07	19.11	14.42	11.02
PEP	99.53	98.36	96.37	38.69	30.83	14.42	12.08	10.43	4.57
VZ	100.00	100.00	99.77	61.55	49.59	33.65	24.74	17.47	11.72
COP	96.01	91.79	85.23	22.63	16.88	14.07	10.20	6.45	5.63
GS	82.06	68.00	25.32	14.89	12.08	6.10	8.91	6.57	3.40
MCD	98.71	95.66	92.61	27.08	20.75	11.14	13.01	10.32	6.33
OXY	86.28	83.59	50.53	16.41	14.42	7.03	8.68	7.15	4.81
ABT	99.77	99.53	98.24	45.25	34.94	23.09	15.94	13.60	6.33
UTX	96.95	94.72	84.64	26.03	19.93	8.91	12.31	9.50	6.21
UPS	97.54	94.37	90.15	25.79	21.10	8.91	12.43	9.14	3.75
F	100.00	100.00	100.00	86.75	78.90	75.03	42.09	34.82	28.02
DIS	99.77	99.53	98.83	40.56	30.95	21.92	13.13	9.96	7.97
MMM	96.25	90.74	80.66	22.86	17.23	8.44	8.44	9.14	5.28
CAT	89.45	74.79	51.00	18.87	11.72	5.74	8.79	6.45	3.87
FCX	89.10	74.33	60.02	17.82	11.37	8.44	9.03	4.92	5.63
USB	100.00	99.77	99.30	54.63	44.20	30.60	20.63	14.30	10.79
MO	100.00	100.00	100.00	86.75	76.44	64.48	38.10	29.54	23.56
AXP	98.83	96.37	92.61	26.85	18.64	13.48	11.49	7.97	6.45
BA	97.42	93.32	81.59	26.38	20.98	7.85	12.78	8.91	4.92
MDT	100.00	100.00	99.18	48.83	35.80	20.89	16.08	12.68	7.75
HD	100.00	99.53	98.71	41.74	29.54	20.16	15.36	10.20	7.97
CVS	100.00	99.41	99.06	48.00	33.80	21.01	14.67	11.38	7.98
EMC	100.00	100.00	99.88	64.95	53.81	37.05	21.10	18.41	10.67
HAL	96.01	91.21	85.23	23.56	14.77	10.32	9.61	7.74	4.92
PNC	97.89	93.08	82.30	25.09	16.53	7.85	11.14	9.26	7.85

Notes: The normality test is implemented for the high-frequency returns (2010-2013) without jump adjustment and the significance level is 5%. The figures are in percentage of proportion of the trading days that reject the normality hypothesis. Total number of trading days of each stock investigated in our paper ranges from 830 to 853.

Table S4: ME and RMSE of daily volatility estimates using the TRV method without subsampling under the CTS scheme

Sparsity	NSR	Model	ME					RMSE				
			1-min	2-min	3-min	5-min	10-min	1-min	2-min	3-min	5-min	10-min
5-sec	0.005%	MD1	0.2765	0.0018	-0.1603	-0.4215	-0.9202	1.8804	2.6007	3.1602	4.0590	5.8376
		MD2	0.0356	-0.0846	-0.1627	-0.3037	-0.6353	1.2804	1.7714	2.1589	2.7816	3.9611
		MD3	0.3045	0.0713	-0.0585	-0.2489	-0.7224	1.7884	2.4828	3.0502	3.9652	5.6334
		MD4	0.4156	0.2356	0.1679	0.0247	-0.4923	1.9250	2.7166	3.3612	4.2869	5.7800
		MD5	0.7956	0.7680	0.8243	0.9138	0.9625	2.1969	2.9971	3.6751	4.7167	6.7030
	0.01%	MD1	1.0475	0.3853	0.0949	-0.2659	-0.8453	2.1758	2.6506	3.1766	4.0599	5.8367
		MD2	0.5479	0.1720	0.0076	-0.2041	-0.5874	1.4343	1.7973	2.1677	2.7840	3.9615
		MD3	1.0395	0.4387	0.1845	-0.1021	-0.6511	2.0729	2.5383	3.0736	3.9702	5.6359
		MD4	1.1810	0.6181	0.4212	0.1775	-0.4130	2.2297	2.7762	3.3845	4.2916	5.7746
		MD5	1.5738	1.1545	1.0821	1.0711	1.0411	2.6187	3.1405	3.7595	4.7610	6.7240
	0.02%	MD1	2.5583	1.1484	0.6060	0.0384	-0.6950	3.2620	2.9186	3.2798	4.0837	5.8387
		MD2	1.5586	0.6783	0.3466	-0.0004	-0.4867	2.1291	1.9585	2.2235	2.7988	3.9643
		MD3	2.4829	1.1694	0.6695	0.1853	-0.5064	3.1055	2.7979	3.1751	4.0007	5.6464
		MD4	2.6748	1.3745	0.9285	0.4797	-0.2590	3.3024	3.0429	3.4905	4.3217	5.7700
		MD5	3.0965	1.9223	1.5958	1.3815	1.1966	3.8041	3.5453	3.9743	4.8697	6.7727
10-sec	0.005%	MD1	-0.2079	-0.1010	-0.1970	-0.4394	-0.9293	1.8557	2.5940	3.1417	4.0793	5.8419
		MD2	-0.2901	-0.1496	-0.1914	-0.3297	-0.6460	1.3079	1.7686	2.1641	2.7849	3.9646
		MD3	-0.1525	-0.0152	-0.1067	-0.2822	-0.7214	1.7672	2.4800	3.0529	3.9676	5.6270
		MD4	0.0570	0.1687	0.1243	-0.0020	-0.5132	1.8638	2.7000	3.3345	4.2761	5.7746
		MD5	0.3063	0.6868	0.7751	0.8785	0.9542	2.0505	2.9700	3.6640	4.7304	6.6935
	0.01%	MD1	0.5875	0.2843	0.0584	-0.2834	-0.8549	1.9722	2.6322	3.1550	4.0786	5.8397
		MD2	0.2392	0.1065	-0.0200	-0.2281	-0.5947	1.3340	1.7817	2.1696	2.7857	3.9646
		MD3	0.5998	0.3509	0.1382	-0.1391	-0.6520	1.8899	2.5251	3.0705	3.9718	5.6282
		MD4	0.8420	0.5530	0.3749	0.1514	-0.4360	2.0561	2.7543	3.3594	4.2797	5.7719
		MD5	1.1028	1.0782	1.0365	1.0340	1.0280	2.3484	3.1071	3.7484	4.7752	6.7165
	0.02%	MD1	2.1353	1.0514	0.5703	0.0207	-0.7064	2.9200	2.8695	3.2476	4.0969	5.8447
		MD2	1.2704	0.6162	0.3200	-0.0283	-0.4953	1.9108	1.9282	2.2218	2.7940	3.9630
		MD3	2.0703	1.0814	0.6230	0.1480	-0.5064	2.7838	2.7605	3.1571	3.9975	5.6322
		MD4	2.3616	1.3139	0.8782	0.4572	-0.2889	3.0457	3.0102	3.4572	4.3033	5.7685
		MD5	2.6595	1.8532	1.5518	1.3425	1.1787	3.4399	3.5026	3.9594	4.8790	6.7581
20-sec	0.005%	MD1	-3.3631	-0.6075	-0.4036	-0.4887	-0.9360	3.8969	2.6448	3.1505	4.0686	5.8363
		MD2	-2.3761	-0.4721	-0.3109	-0.3650	-0.6672	2.7582	1.8149	2.1613	2.7968	3.9626
		MD3	-3.0192	-0.4931	-0.2803	-0.3365	-0.7559	3.5111	2.5065	3.0455	3.9633	5.6222
		MD4	-2.2453	-0.2437	-0.0441	-0.0970	-0.5295	2.9432	2.6686	3.2973	4.2452	5.7747
		MD5	-2.9017	0.1677	0.5882	0.8210	0.9329	3.6002	2.8912	3.6233	4.7002	6.6668
	0.01%	MD1	-2.5819	-0.2065	-0.1414	-0.3367	-0.8616	3.2493	2.6054	3.1512	4.0667	5.8367
		MD2	-1.8555	-0.2040	-0.1397	-0.2630	-0.6202	2.3096	1.7829	2.1573	2.7960	3.9652
		MD3	-2.2787	-0.1109	-0.0339	-0.1870	-0.6846	2.9148	2.4815	3.0467	3.9625	5.6224
		MD4	-1.4825	0.1513	0.2138	0.0542	-0.4511	2.4112	2.6634	3.3044	4.2466	5.7679
		MD5	-2.1231	0.5701	0.8544	0.9801	1.0126	3.0148	2.9675	3.6960	4.7462	6.6840
	0.02%	MD1	-1.0765	0.5809	0.3751	-0.0345	-0.7144	2.2851	2.7121	3.2132	4.0855	5.8370
		MD2	-0.8510	0.3208	0.2058	-0.0558	-0.5176	1.6202	1.8455	2.1936	2.8055	3.9647
		MD3	-0.8468	0.6410	0.4596	0.1059	-0.5399	2.0605	2.6001	3.1160	3.9837	5.6253
		MD4	-0.0140	0.9322	0.7264	0.3574	-0.2999	1.9210	2.8273	3.3794	4.2665	5.7655
		MD5	-0.6113	1.3614	1.3800	1.2937	1.1634	2.2695	3.2667	3.8906	4.8464	6.7261

Notes: ME and RMSE are of the annualized standard deviation in percentage. The average true daily integrated volatility is around 40% for MD1, 27% for MD2, 36% for MD3, 28% for MD4 and 40% for MD5. MD1 and MD2 are the Heston model at different volatility level. MD3 is the two-factor stochastic volatility model with intraday volatility periodicity. MD4 is the deterministic volatility model with intraday volatility periodicity and MD5 is the Heston model (MD1) with price jumps. The first column indicates the average duration of the observed simulated transactions.

Table S5: ME and RMSE of daily volatility estimates using the TRV method without subsampling under the TTS scheme

Sparsity	NSR	Model	ME					RMSE				
			1-min	2-min	3-min	5-min	10-min	1-min	2-min	3-min	5-min	10-min
5-sec	0.005%	MD1	-0.0486	-0.1645	-0.2494	-0.3872	-0.7403	1.8625	2.5866	3.1463	4.0825	5.7765
		MD2	-0.1811	-0.1996	-0.2175	-0.2841	-0.4918	1.2959	1.7819	2.1579	2.7673	3.9429
		MD3	0.0039	-0.0570	-0.1106	-0.1906	-0.5129	1.7806	2.4898	3.0538	3.9685	5.6190
		MD4	0.1888	0.1297	0.1188	0.0329	-0.4067	1.9010	2.7056	3.3554	4.2846	5.7511
		MD5	0.4782	0.6140	0.7428	0.9141	1.1668	2.1260	2.9674	3.6460	4.7036	6.7239
	0.01%	MD1	0.7339	0.2245	0.0067	-0.2307	-0.6617	2.0412	2.6161	3.1551	4.0850	5.7784
		MD2	0.3416	0.0613	-0.0456	-0.1785	-0.4425	1.3667	1.7910	2.1604	2.7716	3.9465
		MD3	0.7511	0.3136	0.1357	-0.0418	-0.4377	1.9593	2.5286	3.0682	3.9741	5.6182
		MD4	0.9657	0.5185	0.3762	0.1855	-0.3297	2.1335	2.7575	3.3737	4.2903	5.7488
		MD5	1.2671	1.0047	1.0037	1.0713	1.2440	2.4692	3.0959	3.7283	4.7519	6.7487
	0.02%	MD1	2.2705	0.9999	0.5199	0.0797	-0.5061	3.0350	2.8399	3.2403	4.1106	5.7844
		MD2	1.3618	0.5754	0.2949	0.0255	-0.3415	1.9848	1.9264	2.2147	2.7907	3.9514
		MD3	2.2102	1.0523	0.6249	0.2517	-0.2942	2.9013	2.7589	3.1564	4.0050	5.6265
		MD4	2.4765	1.2806	0.8859	0.4938	-0.1747	3.1497	3.0070	3.4744	4.3188	5.7457
		MD5	2.8118	1.7841	1.5249	1.3856	1.4003	3.5912	3.4727	3.9386	4.8604	6.8042
10-sec	0.005%	MD1	-0.5513	-0.4358	-0.4229	-0.4977	-0.7675	1.9652	2.6115	3.1903	4.0962	5.7850
		MD2	-0.5171	-0.3709	-0.3367	-0.3680	-0.5283	1.3995	1.8032	2.1732	2.7816	3.9376
		MD3	-0.4485	-0.3124	-0.2851	-0.3108	-0.5679	1.8592	2.4968	3.0428	3.9461	5.6049
		MD4	-0.1800	-0.0730	-0.0693	-0.0616	-0.4648	1.9217	2.6951	3.3350	4.2743	5.7368
		MD5	-0.0295	0.3201	0.5488	0.8034	1.0889	2.0870	2.9066	3.6022	4.7083	6.6976
	0.01%	MD1	0.2402	-0.0316	-0.1606	-0.3406	-0.6884	1.9384	2.6018	3.1851	4.0928	5.7898
		MD2	0.0083	-0.1051	-0.1642	-0.2665	-0.4801	1.3320	1.7881	2.1664	2.7813	3.9387
		MD3	0.2973	0.0694	-0.0347	-0.1637	-0.4923	1.8616	2.5004	3.0480	3.9496	5.6056
		MD4	0.5982	0.3241	0.1942	0.0931	-0.3855	2.0131	2.7150	3.3394	4.2780	5.7357
		MD5	0.7636	0.7256	0.8171	0.9617	1.1642	2.2608	3.0008	3.6723	4.7540	6.7198
	0.02%	MD1	1.7754	0.7654	0.3623	-0.0240	-0.5335	2.6930	2.7658	3.2418	4.1063	5.7931
		MD2	1.0314	0.4247	0.1824	-0.0597	-0.3832	1.7660	1.8755	2.2016	2.7902	3.9396
		MD3	1.7599	0.8255	0.4637	0.1362	-0.3446	2.5947	2.6714	3.1171	3.9706	5.6138
		MD4	2.0993	1.1072	0.7104	0.4038	-0.2292	2.8749	2.9169	3.4103	4.3015	5.7338
		MD5	2.3110	1.5311	1.3481	1.2733	1.3218	3.2132	3.3351	3.8631	4.8561	6.7649
20-sec	0.005%	MD1	-1.5467	-0.9622	-0.7993	-0.7283	-0.8956	2.4372	2.7904	3.2566	4.1020	5.7768
		MD2	-1.1788	-0.7181	-0.5846	-0.5050	-0.5812	1.7536	1.9349	2.2284	2.8114	3.9478
		MD3	-1.3682	-0.8045	-0.6200	-0.5249	-0.6819	2.2428	2.6222	3.0947	3.9504	5.6025
		MD4	-0.9199	-0.4870	-0.3398	-0.2635	-0.5557	2.0994	2.7426	3.3502	4.2524	5.7214
		MD5	-1.0317	-0.2025	0.1975	0.5500	1.0047	2.3152	2.9314	3.5707	4.6778	6.6831
	0.01%	MD1	-0.6734	-0.5496	-0.5349	-0.5673	-0.8201	2.0228	2.6981	3.2233	4.0895	5.7779
		MD2	-0.5992	-0.4502	-0.4083	-0.3976	-0.5312	1.4378	1.8645	2.1985	2.8037	3.9450
		MD3	-0.5402	-0.4180	-0.3659	-0.3737	-0.6084	1.8843	2.5502	3.0716	3.9442	5.6023
		MD4	-0.0651	-0.0843	-0.0740	-0.1068	-0.4749	1.8923	2.7042	3.3363	4.2478	5.7139
		MD5	-0.1532	0.2071	0.4649	0.7054	1.0816	2.1046	2.9532	3.6154	4.7125	6.7001
	0.02%	MD1	1.0071	0.2600	-0.0057	-0.2514	-0.6661	2.2303	2.7010	3.2216	4.0919	5.7790
		MD2	0.5209	0.0848	-0.0555	-0.1874	-0.4308	1.4791	1.8496	2.1860	2.7981	3.9492
		MD3	1.0538	0.3486	0.1407	-0.0751	-0.4653	2.1461	2.5794	3.0836	3.9558	5.6056
		MD4	1.5600	0.7092	0.4478	0.2065	-0.3182	2.4765	2.8021	3.3664	4.2579	5.7108
		MD5	1.5316	1.0172	1.0014	1.0215	1.2331	2.6637	3.1626	3.7584	4.7917	6.7416

Notes: ME and RMSE are of the annualized standard deviation in percentage. The average true daily integrated volatility is around 40% for MD1, 27% for MD2, 36% for MD3, 28% for MD4 and 40% for MD5. MD1 and MD2 are the Heston model at different volatility level. MD3 is the two-factor stochastic volatility model with intraday volatility periodicity. MD4 is the deterministic volatility model with intraday volatility periodicity and MD5 is the Heston model (MD1) with price jumps. The first column indicates the average duration of the observed simulated transactions.

Table S6: ME and RMSE of daily volatility estimates using the TRV method without subsampling under the BTS scheme

Sparsity	NSR	Model	ME					RMSE				
			1-min	2-min	3-min	5-min	10-min	1-min	2-min	3-min	5-min	10-min
5-sec	0.005%	MD1	-0.7386	-0.0642	0.0913	0.1680	0.1851	1.9218	2.4472	2.9922	3.9446	5.6809
		MD2	-0.6463	-0.1267	-0.0021	0.0488	0.0874	1.3902	1.6765	2.0488	2.6698	3.8747
		MD3	-0.6402	-0.1384	0.0125	0.1026	0.1165	1.7261	2.1962	2.6836	3.4978	5.0122
		MD4	-0.3995	-0.2969	-0.2174	-0.0985	-0.0731	1.4002	1.8229	2.1778	2.7810	3.9711
		MD5	-0.4117	0.3786	0.6509	1.0585	1.7189	1.9117	2.5964	3.2405	4.3322	6.4623
	0.01%	MD1	0.1085	0.3520	0.3439	0.3142	0.2626	1.8267	2.5061	3.0464	3.9573	5.6974
		MD2	-0.0949	0.1486	0.1742	0.1869	0.1258	1.2590	1.7014	2.0785	2.7004	3.8801
		MD3	0.1551	0.2208	0.2532	0.2680	0.1935	1.6491	2.2327	2.6967	3.5108	5.0458
		MD4	0.3948	0.1199	0.0535	0.0674	-0.0045	1.4381	1.8333	2.2001	2.8060	4.0164
		MD5	0.4446	0.8077	0.9476	1.2144	1.7896	1.9562	2.7180	3.3357	4.3813	6.4896
	0.02%	MD1	1.7358	1.1392	0.8667	0.6163	0.3780	2.5885	2.7845	3.2021	4.0384	5.7294
		MD2	0.9993	0.6754	0.5228	0.3796	0.2312	1.6857	1.8834	2.1614	2.7484	3.8905
		MD3	1.7085	1.0048	0.7713	0.5630	0.3422	2.4225	2.4853	2.8486	3.5908	5.0948
		MD4	1.9701	0.9155	0.6078	0.3855	0.1686	2.4677	2.1045	2.3352	2.8921	4.0595
		MD5	2.1045	1.6356	1.4884	1.5421	1.9414	2.9157	3.1288	3.5805	4.5353	6.5625
10-sec	0.005%	MD1	-1.1362	-0.2800	-0.0021	0.1282	0.1350	2.1189	2.4638	2.9893	3.9077	5.6843
		MD2	-0.9108	-0.2736	-0.0638	0.0594	0.0915	1.5407	1.6856	2.0465	2.6697	3.8474
		MD3	-1.0175	-0.3829	-0.1136	0.0598	0.0812	1.9128	2.2274	2.6643	3.4810	5.0171
		MD4	-0.7556	-0.5138	-0.3702	-0.2073	-0.1186	1.5765	1.8882	2.2048	2.8001	3.9377
		MD5	-0.8024	0.1483	0.5708	0.9862	1.7288	2.0396	2.5735	3.2257	4.2856	6.4519
	0.01%	MD1	-0.2648	0.1410	0.2729	0.3009	0.2069	1.8299	2.4731	3.0344	3.9613	5.6767
		MD2	-0.3312	-0.0040	0.1217	0.1688	0.1481	1.2977	1.6873	2.0651	2.6968	3.8538
		MD3	-0.2125	0.0277	0.1589	0.2442	0.1779	1.6604	2.2178	2.7075	3.5036	5.0578
		MD4	0.0357	-0.0954	-0.0744	-0.0169	-0.0381	1.4169	1.8405	2.2106	2.8133	3.9915
		MD5	0.0877	0.6132	0.8651	1.1572	1.7822	1.9288	2.6727	3.3108	4.3771	6.4703
	0.02%	MD1	1.4171	0.9876	0.8335	0.6269	0.3334	2.3837	2.7309	3.1873	4.0413	5.7200
		MD2	0.7940	0.5659	0.4916	0.3681	0.2306	1.5695	1.8326	2.1714	2.7429	3.8912
		MD3	1.3803	0.8448	0.7130	0.5402	0.3251	2.2088	2.4267	2.8389	3.5947	5.1065
		MD4	1.6123	0.7335	0.4714	0.3079	0.1404	2.2035	2.0324	2.2972	2.8741	4.0367
		MD5	1.7771	1.4778	1.4441	1.5273	1.9046	2.6918	3.0593	3.5680	4.5321	6.5540
20-sec	0.005%	MD1	-1.5495	-0.6087	-0.2302	0.0096	-0.0024	2.4113	2.5365	3.0181	3.9089	5.6326
		MD2	-1.1726	-0.4957	-0.2067	-0.0391	-0.0072	1.7383	1.7595	2.0742	2.6700	3.8550
		MD3	-1.4348	-0.6843	-0.3349	-0.0682	0.0042	2.2082	2.3088	2.7062	3.4933	4.9995
		MD4	-1.1779	-0.8037	-0.6032	-0.3917	-0.2569	1.9163	2.0454	2.2940	2.8240	3.9595
		MD5	-1.1827	-0.1329	0.3770	0.8899	1.5604	2.2991	2.6091	3.2144	4.3198	6.4341
	0.01%	MD1	-0.6885	-0.1516	0.0716	0.1681	0.0729	1.9918	2.4967	3.0271	3.9504	5.6821
		MD2	-0.5947	-0.1963	-0.0180	0.0570	0.0278	1.4211	1.7180	2.0724	2.6869	3.8598
		MD3	-0.6264	-0.2355	-0.0294	0.1117	0.0690	1.8182	2.2514	2.7065	3.5107	5.0339
		MD4	-0.4162	-0.3635	-0.3065	-0.2071	-0.1711	1.5767	1.9369	2.2577	2.8166	3.9762
		MD5	-0.3131	0.3306	0.7023	1.0783	1.6439	2.0171	2.6669	3.3037	4.3704	6.5018
	0.02%	MD1	0.9673	0.7576	0.6773	0.4931	0.2356	2.1770	2.6631	3.1650	4.0161	5.7011
		MD2	0.5051	0.4091	0.3836	0.3007	0.1155	1.4548	1.8036	2.1500	2.7316	3.8792
		MD3	0.9340	0.6284	0.5359	0.4205	0.2121	2.0075	2.3824	2.8064	3.5834	5.1012
		MD4	1.1059	0.5034	0.3007	0.1720	0.0337	1.9364	2.0141	2.3149	2.8809	4.0862
		MD5	1.3600	1.2454	1.3184	1.4304	1.7997	2.4864	2.9726	3.5423	4.5144	6.5563

Notes: ME and RMSE are of the annualized standard deviation in percentage. The average true daily integrated volatility is around 40% for MD1, 27% for MD2, 36% for MD3, 28% for MD4 and 40% for MD5. MD1 and MD2 are the Heston model at different volatility level. MD3 is the two-factor stochastic volatility model with intraday volatility periodicity. MD4 is the deterministic volatility model with intraday volatility periodicity and MD5 is the Heston model (MD1) with price jumps. The first column indicates the average duration of the observed simulated transactions.

Table S7: ME and RMSE of daily volatility estimates using the TRV method with subsampling under the CTS scheme

Sparsity	NSR	Model	ME					RMSE				
			1-min	2-min	3-min	5-min	10-min	1-min	2-min	3-min	5-min	10-min
5-sec	0.005%	MD1	0.2968	0.0332	-0.1110	-0.3157	-0.7328	1.3470	1.8355	2.2431	2.9109	4.1736
		MD2	0.0464	-0.0588	-0.1266	-0.2462	-0.4917	0.9051	1.2467	1.5296	1.9877	2.8346
		MD3	0.2855	0.0506	-0.0949	-0.3215	-0.8718	1.2761	1.7448	2.1428	2.7859	3.9621
		MD4	0.3617	0.1186	-0.0331	-0.3395	-1.1888	1.3787	1.8834	2.3030	2.9214	3.9184
		MD5	0.8233	0.8215	0.8752	0.9928	1.1545	1.7400	2.3406	2.8583	3.6844	5.2112
	0.01%	MD1	1.0698	0.4202	0.1473	-0.1607	-0.6541	1.6907	1.8630	2.2249	2.8801	4.1466
		MD2	0.5617	0.1989	0.0455	-0.1427	-0.4400	1.0791	1.2513	1.5122	1.9659	2.8164
		MD3	1.0234	0.4194	0.1516	-0.1723	-0.7967	1.5991	1.7737	2.1267	2.7559	3.9334
		MD4	1.1287	0.5029	0.2245	-0.1830	-1.1079	1.7312	1.9213	2.2907	2.8879	3.8802
		MD5	1.6017	1.2112	1.1359	1.1498	1.2340	2.2173	2.4900	2.9326	3.7154	5.2177
	0.02%	MD1	2.5864	1.1887	0.6611	0.1485	-0.4973	2.9151	2.1454	2.2829	2.8455	4.0972
		MD2	1.5734	0.7087	0.3868	0.0631	-0.3363	1.8739	1.4190	1.5412	1.9392	2.7833
		MD3	2.4694	1.1504	0.6410	0.1240	-0.6466	2.7515	2.0426	2.1817	2.7200	3.8799
		MD4	2.6275	1.2649	0.7371	0.1286	-0.9467	2.9351	2.2114	2.3560	2.8479	3.8090
		MD5	3.1305	1.9841	1.6540	1.4628	1.3917	3.5031	2.9285	3.1449	3.7972	5.2348
10-sec	0.005%	MD1	-0.1986	-0.0693	-0.1605	-0.3369	-0.7443	1.3738	1.8617	2.2630	2.9232	4.1799
		MD2	-0.2806	-0.1265	-0.1592	-0.2615	-0.5001	0.9729	1.2699	1.5451	1.9959	2.8382
		MD3	-0.1666	-0.0480	-0.1414	-0.3473	-0.8851	1.3000	1.7749	2.1625	2.7984	3.9685
		MD4	0.0062	0.0435	-0.0719	-0.3596	-1.1973	1.3743	1.9063	2.3208	2.9327	3.9241
		MD5	0.3180	0.7174	0.8221	0.9677	1.1403	1.5978	2.3272	2.8530	3.6881	5.2092
	0.01%	MD1	0.5931	0.3192	0.0976	-0.1820	-0.6660	1.4841	1.8743	2.2426	2.8932	4.1538
		MD2	0.2478	0.1332	0.0129	-0.1578	-0.4484	0.9771	1.2632	1.5277	1.9745	2.8199
		MD3	0.5889	0.3225	0.1055	-0.1991	-0.8103	1.4141	1.7890	2.1445	2.7689	3.9401
		MD4	0.7929	0.4314	0.1863	-0.2033	-1.1160	1.5752	1.9329	2.3062	2.8995	3.8864
		MD5	1.1170	1.1088	1.0847	1.1244	1.2191	1.9286	2.4652	2.9259	3.7205	5.2165
	0.02%	MD1	2.1409	1.0900	0.6120	0.1277	-0.5098	2.5611	2.1284	2.2948	2.8594	4.1057
		MD2	1.2809	0.6472	0.3555	0.0481	-0.3451	1.6459	1.4147	1.5539	1.9481	2.7873
		MD3	2.0635	1.0573	0.5956	0.0964	-0.6603	2.4335	2.0308	2.1953	2.7352	3.8878
		MD4	2.3179	1.1985	0.6992	0.1084	-0.9546	2.6907	2.2043	2.3668	2.8602	3.8159
		MD5	2.6775	1.8878	1.6048	1.4370	1.3775	3.1293	2.8890	3.1360	3.8034	5.2342
20-sec	0.005%	MD1	-3.3553	-0.5888	-0.3606	-0.4217	-0.7800	3.7019	2.0158	2.3321	2.9616	4.2012
		MD2	-2.3673	-0.4691	-0.2902	-0.3118	-0.5229	2.6247	1.3902	1.5939	2.0268	2.8530
		MD3	-3.0215	-0.5208	-0.3260	-0.4202	-0.9125	3.3293	1.8981	2.2234	2.8353	3.9885
		MD4	-2.2783	-0.3384	-0.2228	-0.4241	-1.2220	2.7230	1.9950	2.3731	2.9674	3.9414
		MD5	-2.8934	0.1894	0.6246	0.8867	1.1063	3.3754	2.2727	2.8414	3.6921	5.2141
	0.01%	MD1	-2.5748	-0.1880	-0.0983	-0.2653	-0.7011	2.9972	1.9304	2.2952	2.9308	4.1765
		MD2	-1.8486	-0.2026	-0.1163	-0.2079	-0.4711	2.1414	1.3196	1.5647	2.0046	2.8359
		MD3	-2.2816	-0.1378	-0.0753	-0.2710	-0.8380	2.6767	1.8243	2.1903	2.8057	3.9609
		MD4	-1.5119	0.0588	0.0394	-0.2671	-1.1411	2.1076	1.9520	2.3457	2.9330	3.9030
		MD5	-2.1120	0.5936	0.8898	1.0450	1.1849	2.7219	2.3378	2.9036	3.7237	5.2218
	0.02%	MD1	-1.0688	0.6032	0.4232	0.0452	-0.5451	1.8517	2.0081	2.3156	2.8965	4.1306
		MD2	-0.8447	0.3238	0.2298	-0.0002	-0.3675	1.3346	1.3489	1.5690	1.9776	2.8039
		MD3	-0.8505	0.6145	0.4210	0.0258	-0.6879	1.6498	1.9103	2.2098	2.7699	3.9106
		MD4	-0.0426	0.8431	0.5573	0.0443	-0.9808	1.4504	2.1023	2.3809	2.8916	3.8335
		MD5	-0.5983	1.3892	1.4158	1.3596	1.3408	1.8062	2.6532	3.0935	3.8061	5.2409

Notes: ME and RMSE are of the annualized standard deviation in percentage. The average true daily integrated volatility is around 40% for MD1, 27% for MD2, 36% for MD3, 28% for MD4 and 40% for MD5. MD1 and MD2 are the Heston model at different volatility level. MD3 is the two-factor stochastic volatility model with intraday volatility periodicity. MD4 is the deterministic volatility model with intraday volatility periodicity and MD5 is the Heston model (MD1) with price jumps. The first column indicates the average duration of the observed simulated transactions.

Table S8: ME and RMSE of daily volatility estimates using the TRV method with subsampling under the TTS scheme

Sparsity	NSR	Model	ME					RMSE				
			1-min	2-min	3-min	5-min	10-min	1-min	2-min	3-min	5-min	10-min
5-sec	0.005%	MD1	-0.0517	-0.1758	-0.2597	-0.4047	-0.7809	1.3130	1.8416	2.2588	2.9293	4.1866
		MD2	-0.1824	-0.1986	-0.2244	-0.3025	-0.5233	0.9132	1.2584	1.5419	1.9989	2.8422
		MD3	-0.0293	-0.1394	-0.2269	-0.4029	-0.9162	1.2428	1.7475	2.1521	2.7986	3.9739
		MD4	0.1113	-0.0348	-0.1454	-0.4131	-1.2243	1.3307	1.8849	2.3105	2.9296	3.9347
		MD5	0.4782	0.6174	0.7243	0.8982	1.1101	1.6043	2.2772	2.8182	3.6622	5.1995
	0.01%	MD1	0.7340	0.2171	0.0021	-0.2481	-0.7017	1.4892	1.8218	2.2209	2.8926	4.1580
		MD2	0.3415	0.0625	-0.0507	-0.1984	-0.4712	0.9629	1.2311	1.5114	1.9728	2.8230
		MD3	0.7199	0.2349	0.0223	-0.2529	-0.8404	1.4171	1.7349	2.1186	2.7628	3.9436
		MD4	0.8908	0.3555	0.1154	-0.2555	-1.1430	1.5773	1.8896	2.2835	2.8914	3.8950
		MD5	1.2689	1.0131	0.9879	1.0568	1.1894	1.9802	2.3968	2.8792	3.6887	5.2048
	0.02%	MD1	2.2717	0.9948	0.5212	0.0635	-0.5444	2.6235	2.0319	2.2421	2.8465	4.1057
		MD2	1.3660	0.5791	0.2948	0.0090	-0.3670	1.6798	1.3472	1.5159	1.9382	2.7879
		MD3	2.1836	0.9759	0.5173	0.0456	-0.6897	2.4897	1.9411	2.1421	2.7169	3.8877
		MD4	2.4054	1.1268	0.6331	0.0588	-0.9813	2.7283	2.1318	2.3233	2.8417	3.8208
		MD5	2.8163	1.7964	1.5130	1.3722	1.3472	3.2105	2.7970	3.0698	3.7630	5.2200
10-sec	0.005%	MD1	-0.5516	-0.4487	-0.4361	-0.5224	-0.8358	1.4790	1.9039	2.2990	2.9580	4.2085
		MD2	-0.5129	-0.3793	-0.3494	-0.3808	-0.5574	1.0656	1.3125	1.5773	2.0197	2.8519
		MD3	-0.4819	-0.3884	-0.4015	-0.5122	-0.9712	1.3894	1.8081	2.1963	2.8303	3.9928
		MD4	-0.2505	-0.2400	-0.2896	-0.5027	-1.2683	1.4059	1.9158	2.3326	2.9460	3.9521
		MD5	-0.0248	0.3341	0.5398	0.7829	1.0467	1.5891	2.2287	2.7879	3.6465	5.1956
	0.01%	MD1	0.2364	-0.0451	-0.1707	-0.3643	-0.7566	1.3765	1.8287	2.2422	2.9157	4.1797
		MD2	0.0132	-0.1109	-0.1730	-0.2760	-0.5052	0.9300	1.2483	1.5338	1.9901	2.8323
		MD3	0.2681	-0.0040	-0.1493	-0.3617	-0.8952	1.3166	1.7460	2.1455	2.7892	3.9618
		MD4	0.5300	0.1618	-0.0235	-0.3432	-1.1865	1.4605	1.8814	2.2906	2.9031	3.9119
		MD5	0.7703	0.7409	0.8070	0.9428	1.1259	1.7564	2.3086	2.8352	3.6692	5.2007
	0.02%	MD1	1.7736	0.7541	0.3566	-0.0494	-0.5989	2.2414	1.9473	2.2272	2.8581	4.1262
		MD2	1.0392	0.4206	0.1775	-0.0671	-0.4010	1.4356	1.3033	1.5124	1.9480	2.7963
		MD3	1.7329	0.7567	0.3539	-0.0612	-0.7437	2.1514	1.8708	2.1337	2.7332	3.9052
		MD4	2.0392	0.9541	0.5017	-0.0268	-1.0242	2.4452	2.0641	2.3026	2.8455	3.8372
		MD5	2.3202	1.5468	1.3390	1.2604	1.2850	2.8184	2.6578	3.0024	3.7363	5.2146
20-sec	0.005%	MD1	-1.5456	-0.9755	-0.8101	-0.7508	-0.9624	2.1294	2.1667	2.4446	3.0322	4.2458
		MD2	-1.1754	-0.7228	-0.5899	-0.5349	-0.6353	1.5498	1.5021	1.6784	2.0747	2.8870
		MD3	-1.3862	-0.8709	-0.7288	-0.7174	-1.0831	1.9469	2.0256	2.3181	2.8971	4.0378
		MD4	-0.9656	-0.6310	-0.5652	-0.6721	-1.3640	1.7472	2.0611	2.4288	3.0082	3.9960
		MD5	-1.0312	-0.1876	0.1763	0.5540	0.9132	1.9665	2.2887	2.7769	3.6325	5.1833
	0.01%	MD1	-0.6723	-0.5651	-0.5403	-0.5906	-0.8826	1.5976	1.9994	2.3519	2.9801	4.2153
		MD2	-0.5942	-0.4507	-0.4112	-0.4286	-0.5833	1.1564	1.3784	1.6107	2.0385	2.8665
		MD3	-0.5574	-0.4809	-0.4722	-0.5639	-1.0070	1.4725	1.8769	2.2341	2.8474	4.0056
		MD4	-0.1095	-0.2245	-0.2953	-0.5106	-1.2820	1.4410	1.9525	2.3592	2.9575	3.9539
		MD5	-0.1518	0.2245	0.4473	0.7158	0.9933	1.6700	2.2787	2.7934	3.6475	5.1874
	0.02%	MD1	1.0095	0.2420	-0.0044	-0.2698	-0.7231	1.7813	1.9083	2.2582	2.9023	4.1593
		MD2	0.5272	0.0861	-0.0554	-0.2161	-0.4775	1.1592	1.2928	1.5381	1.9830	2.8277
		MD3	1.0376	0.2876	0.0374	-0.2591	-0.8542	1.7195	1.8116	2.1543	2.7751	3.9461
		MD4	1.5196	0.5736	0.2358	-0.1903	-1.1188	2.0884	1.9865	2.3133	2.8833	3.8762
		MD5	1.5376	1.0383	0.9871	1.0383	1.1526	2.2818	2.4775	2.9055	3.7002	5.1988

Notes: ME and RMSE are of the annualized standard deviation in percentage. The average true daily integrated volatility is around 40% for MD1, 27% for MD2, 36% for MD3, 28% for MD4 and 40% for MD5. MD1 and MD2 are the Heston model at different volatility level. MD3 is the two-factor stochastic volatility model with intraday volatility periodicity. MD4 is the deterministic volatility model with intraday volatility periodicity and MD5 is the Heston model (MD1) with price jumps. The first column indicates the average duration of the observed simulated transactions.

Table S9: ME and RMSE of daily volatility using the TRV method with subsampling under the BTS scheme

Sparsity	NSR	Model	ME					RMSE				
			1-min	2-min	3-min	5-min	10-min	1-min	2-min	3-min	5-min	10-min
5-sec	0.005%	MD1	-0.4286	0.0470	0.0031	0.0004	-0.1777	1.3869	1.7228	2.1610	2.8165	4.0975
		MD2	-0.4321	-0.0500	-0.0513	-0.0338	-0.1309	0.9964	1.1706	1.4665	1.9242	2.7797
		MD3	-0.4435	0.0200	0.0123	-0.0019	-0.1916	1.2425	1.5657	1.9431	2.5511	3.6823
		MD4	-0.2403	-0.0913	0.0126	0.0055	-0.2069	1.0574	1.3723	1.6849	2.2278	3.2164
		MD5	-0.0687	0.6282	0.7732	1.0940	1.6463	1.4163	2.0196	2.5587	3.4485	5.2161
	0.01%	MD1	0.3382	0.4486	0.2625	0.1532	-0.1142	1.3520	1.7646	2.1562	2.8077	4.0850
		MD2	0.0786	0.2172	0.1192	0.0675	-0.0884	0.9049	1.1831	1.4608	1.9152	2.7695
		MD3	0.3291	0.4002	0.2555	0.1439	-0.1301	1.2126	1.6016	1.9521	2.5460	3.6734
		MD4	0.5904	0.3128	0.2734	0.1532	-0.1474	1.1809	1.4043	1.7059	2.2373	3.2230
		MD5	0.7280	1.0331	1.0365	1.2492	1.7128	1.5989	2.1671	2.6391	3.4936	5.2306
	0.02%	MD1	1.8463	1.2523	0.7789	0.4499	0.0126	2.2762	2.1053	2.2506	2.8148	4.0590
		MD2	1.0802	0.7479	0.4603	0.2651	-0.0059	1.4503	1.3864	1.5109	1.9145	2.7529
		MD3	1.7862	1.1644	0.7397	0.4265	-0.0167	2.1440	1.9166	2.0542	2.5558	3.6603
		MD4	2.2616	1.1036	0.7889	0.4437	-0.0291	2.4966	1.7643	1.8609	2.2798	3.2357
		MD5	2.2713	1.8503	1.5649	1.5559	1.8424	2.7080	2.6518	2.8753	3.5982	5.2587
10-sec	0.005%	MD1	-0.9375	-0.0435	-0.0307	-0.0333	-0.1880	1.6335	1.8357	2.1600	2.8457	4.1021
		MD2	-0.8123	-0.1034	-0.0778	-0.0560	-0.1417	1.2304	1.2500	1.4735	1.9394	2.7833
		MD3	-0.8436	-0.0958	-0.0423	-0.0340	-0.2088	1.4854	1.6584	1.9742	2.5751	3.7013
		MD4	-0.5797	-0.2436	-0.0830	-0.0584	-0.2432	1.2715	1.4404	1.7121	2.2547	3.2308
		MD5	-0.5986	0.5429	0.7290	1.0637	1.6334	1.5659	2.0991	2.5573	3.4711	5.2171
	0.01%	MD1	0.0713	0.3397	0.2356	0.1224	-0.1251	1.3501	1.8561	2.1611	2.8355	4.0856
		MD2	-0.1345	0.1520	0.1010	0.0460	-0.0992	0.9467	1.2544	1.4661	1.9323	2.7757
		MD3	0.1028	0.2815	0.2097	0.1090	-0.1529	1.2390	1.6800	1.9774	2.5686	3.6909
		MD4	0.3144	0.1905	0.1929	0.0949	-0.1830	1.1801	1.4321	1.7293	2.2613	3.2356
		MD5	0.4190	0.9362	0.9980	1.2244	1.6968	1.5275	2.2311	2.6363	3.5126	5.2337
	0.02%	MD1	2.0479	1.1137	0.7770	0.4235	-0.0051	2.5005	2.1285	2.2661	2.8358	4.0650
		MD2	1.1815	0.6675	0.4586	0.2426	-0.0175	1.5885	1.4198	1.5277	1.9301	2.7608
		MD3	1.9622	1.0222	0.7158	0.3933	-0.0340	2.3465	1.9448	2.0766	2.5855	3.6804
		MD4	2.1082	1.0387	0.7207	0.3933	-0.0644	2.4205	1.7728	1.8823	2.2997	3.2520
		MD5	2.4111	1.7259	1.5437	1.5352	1.8277	2.8718	2.6669	2.8772	3.6225	5.2623
20-sec	0.005%	MD1	-1.9043	-0.4650	-0.1715	-0.1586	-0.3052	2.5154	1.9081	2.3632	2.8884	4.1176
		MD2	-1.4513	-0.3972	-0.1718	-0.1551	-0.2189	1.8465	1.3232	1.6142	1.9728	2.8010
		MD3	-1.7349	-0.4945	-0.1976	-0.1617	-0.3245	2.2880	1.7421	2.0996	2.6517	3.7326
		MD4	-1.3673	-0.5413	-0.2730	-0.2261	-0.3586	1.9372	1.6463	1.8101	2.3044	3.2759
		MD5	-1.5684	0.0539	0.6149	0.9467	1.5263	2.3452	2.0185	2.7000	3.4925	5.2178
	0.01%	MD1	-0.7727	0.0595	0.0795	-0.0012	-0.2474	1.8388	1.8658	2.3619	2.8691	4.1079
		MD2	-0.6930	-0.0470	-0.0025	-0.0515	-0.1798	1.3436	1.2747	1.6111	1.9649	2.7898
		MD3	-0.6715	0.0110	0.0681	-0.0090	-0.2678	1.6684	1.6857	2.1131	2.6393	3.7245
		MD4	-0.3601	-0.0577	0.0292	-0.0623	-0.3056	1.4354	1.5473	1.7854	2.3140	3.2870
		MD5	-0.4358	0.5872	0.8854	1.1072	1.5868	1.8245	2.1169	2.7876	3.5323	5.2285
	0.02%	MD1	1.4062	1.0834	0.5790	0.3089	-0.1229	2.2543	2.1942	2.4346	2.8722	4.0765
		MD2	0.7467	0.6389	0.3302	0.1612	-0.0953	1.4646	1.4674	1.6470	1.9576	2.7740
		MD3	1.3598	0.9923	0.5629	0.2802	-0.1573	2.1106	1.9812	2.2102	2.6445	3.7064
		MD4	1.6100	0.9172	0.6508	0.2535	-0.1811	2.1813	1.8069	1.9153	2.3599	3.2984
		MD5	1.7450	1.6299	1.4063	1.4237	1.7176	2.5623	2.6474	3.0191	3.6372	5.2592

Notes: ME and RMSE are of the annualized standard deviation in percentage. The average true daily integrated volatility is around 40% for MD1, 27% for MD2, 36% for MD3, 28% for MD4 and 40% for MD5. MD1 and MD2 are the Heston model at different volatility level. MD3 is the two-factor stochastic volatility model with intraday volatility periodicity. MD4 is the deterministic volatility model with intraday volatility periodicity and MD5 is the Heston model (MD1) with price jumps. The first column indicates the average duration of the observed simulated transactions. The sampling frequency of the BTS scheme equals to twice the average transaction duration.

Table S10: ME and RMSE of daily volatility estimates of the RK and ACD-ICV methods for Model MD2

Sparsity	NSR	ME					RMSE								
		RK	ACD-ICV	Avg. sampling frequency (ACD-ICV)					RK	ACD-ICV	Avg. sampling frequency (ACD-ICV)				
				1-min	3-min	5-min	10-min	15-min			1-min	3-min	5-min	10-min	15-min
5-sec	0.005%	-0.0554	ME1	-3.7334	-2.1773	-1.6815	-1.1075	-0.8023	1.5658	ME1	4.2642	2.6916	2.3084	2.1126	2.1477
			ME2	-0.0282	-0.0874	-0.0893	-0.0093	0.0975		ME2	1.6114	1.4167	1.5023	1.7761	1.9821
			ME3	-0.1101	-0.0087	0.1370	0.2380	0.4272		ME3	0.8800	0.9494	1.1542	0.9745	1.0777
	0.01%	-0.0417	ME1	-2.1706	-1.2209	-0.9427	-0.6030	-0.3953	1.5672	ME1	2.7892	1.8687	1.7655	1.8571	2.0231
			ME2	0.0931	0.0477	0.0556	0.1425	0.2551		ME2	1.5181	1.3601	1.4705	1.7590	1.9984
			ME3	0.0629	0.1609	0.3026	0.4080	0.5997		ME3	0.8433	0.9261	1.1347	1.0027	1.1378
	0.02%	-0.0147	ME1	1.1040	0.5697	0.3923	0.3011	0.3363	1.5703	ME1	1.8511	1.4601	1.5144	1.7720	2.0300
			ME2	0.3425	0.3309	0.3546	0.4534	0.5803		ME2	1.4140	1.3708	1.5045	1.8071	2.0864
			ME3	0.4075	0.4979	0.6377	0.7500	0.9453		ME3	0.8902	0.9884	1.2067	1.1571	1.3336
10-sec	0.005%	-0.0751	ME1	-7.1362	-3.9157	-2.9626	-1.9998	-1.5156	1.7937	ME1	7.7312	4.3933	3.4815	2.7513	2.5519
			ME2	-0.0467	-0.1531	-0.1661	-0.1066	0.0051		ME2	2.0058	1.5586	1.5798	1.7972	2.0045
			ME3	-0.1574	-0.1860	-0.0314	0.1258	0.3150		ME3	1.0752	0.9808	1.0817	1.0054	1.0842
	0.01%	-0.0599	ME1	-5.7284	-3.1380	-2.3711	-1.5900	-1.1781	1.7954	ME1	6.2967	3.6246	2.9215	2.4286	2.3437
			ME2	0.0923	0.0009	-0.0105	0.0578	0.1712		ME2	1.8501	1.4889	1.5312	1.7770	2.0051
			ME3	0.0175	-0.0083	0.1497	0.2992	0.4906		ME3	1.0274	0.9357	1.0661	1.0207	1.1304
	0.02%	-0.0294	ME1	-3.1350	-1.6696	-1.2830	-0.8363	-0.5822	1.7983	ME1	3.7327	2.2514	2.0041	1.9572	2.0764
			ME2	0.4040	0.3022	0.3028	0.3849	0.4983		ME2	1.6709	1.4263	1.5193	1.8024	2.0552
			ME3	0.3654	0.3408	0.4923	0.6466	0.8419		ME3	1.0312	0.9639	1.1165	1.1487	1.3071
20-sec	0.005%	-0.1078	ME1	-11.3529	-6.1908	-4.7306	-3.1880	-2.4821	2.0838	ME1	12.1410	6.7322	5.2491	3.8280	3.3078
			ME2	-0.1409	-0.3073	-0.3393	-0.2906	-0.1960		ME2	2.6834	1.8420	1.7730	1.9061	2.0670
			ME3	-0.2602	-0.3610	-0.2607	-0.1048	0.0867		ME3	1.7642	1.1645	1.2405	1.0845	1.1195
	0.01%	-0.0907	ME1	-10.1662	-5.6344	-4.2923	-2.8841	-2.2187	2.0856	ME1	10.9460	6.1576	4.7993	3.5372	3.0841
			ME2	0.0236	-0.1482	-0.1796	-0.1280	-0.0246		ME2	2.5716	1.7486	1.6904	1.8563	2.0394
			ME3	-0.0823	-0.1821	-0.0793	0.0740	0.2668		ME3	1.7119	1.0965	1.1938	1.0646	1.1348
	0.02%	-0.0571	ME1	-8.3626	-4.5732	-3.4209	-2.2876	-1.7304	2.0893	ME1	9.0708	5.0768	3.9382	3.0069	2.7036
			ME2	0.3623	0.1767	0.1515	0.2106	0.3181		ME2	2.4080	1.6406	1.6133	1.8301	2.0390
			ME3	0.2731	0.1757	0.2878	0.4300	0.6247		ME3	1.6765	1.0623	1.2123	1.1294	1.2590

Notes: ME and RMSE are of the annualized standard deviation in percentage. MD2 is the Heston model and the average true daily integrated volatility is around 27%. ME1 is the ACD-ICV method in Tse and Yang (2012). ME2 is ME1 with δ^2 replaced by V_D , the integrated volatility estimated using TRV with subsampling at 3-min sampling frequency. ME3 is ME2 with sampled durations computed from BTS returns. All ACD models are fitted to diurnally transformed durations using the time-transformation function based on the number of trades as in Tse and Dong (2014).

Table S11: ME and RMSE of daily volatility estimates of the RK and ACD-ICV methods for Model MD3

Sparsity	NSR	RK	ACD-ICV	ME					RK	ACD-ICV	RMSE				
				Avg. sampling frequency (ACD-ICV)							Avg. sampling frequency (ACD-ICV)				
				1-min	3-min	5-min	10-min	15-min			1-min	3-min	5-min	10-min	15-min
5-sec	0.005%	-0.0985	ME1	-5.1430	-2.9821	-2.2665	-1.6531	-1.5058	2.1510	ME1	5.2778	3.1797	2.5494	2.3407	2.6393
		ME2	-0.1392	-0.0764	-0.0110	-0.0779	-0.2105	ME2	1.1546	1.0977	1.1627	1.7015	2.2357		
		ME3	-0.1278	-0.0437	0.0464	0.2487	0.4009	ME3	1.1012	1.1052	1.0151	1.0186	1.1564		
	0.01%	-0.0784	ME1	-2.8997	-1.6472	-1.2278	-0.9581	-0.9320	2.1529	ME1	3.1170	1.9593	1.6827	1.9562	2.3715
		ME2	0.1041	0.1734	0.2389	0.1467	0.0340	ME2	1.1343	1.0815	1.1765	1.7429	2.2203		
		ME3	0.1213	0.2033	0.2958	0.4998	0.6496	ME3	1.0659	1.1191	1.0287	1.0839	1.2589		
	0.02%	-0.0389	ME1	1.7384	0.8618	0.6599	0.2937	0.0912	2.1569	ME1	2.0370	1.3384	1.3060	1.8157	2.2471
		ME2	0.6048	0.6700	0.7349	0.6094	0.5208	ME2	1.2157	1.2370	1.3525	1.9015	2.3172		
		ME3	0.6152	0.6992	0.7930	1.0000	1.1425	ME3	1.1817	1.2374	1.2195	1.3586	1.5773		
10-sec	0.005%	-0.1400	ME1	-9.8054	-5.3835	-4.0509	-2.9244	-2.4936	2.4629	ME1	9.9038	5.5136	4.2308	3.3837	3.2661
		ME2	-0.3045	-0.2414	-0.1779	-0.3024	-0.3838	ME2	1.2664	1.1600	1.2053	1.8027	2.2380		
		ME3	-0.2861	-0.2256	-0.1295	0.0859	0.2311	ME3	1.0727	1.3510	1.2577	1.0275	1.1793		
	0.01%	-0.1176	ME1	-7.5214	-4.2769	-3.2264	-2.3623	-2.0371	2.4649	ME1	7.6449	4.4290	3.4421	2.9256	2.9415
		ME2	-0.0509	0.0108	0.0731	-0.0564	-0.1365	ME2	1.2023	1.1152	1.1856	1.7991	2.2139		
		ME3	-0.0344	0.0267	0.1246	0.3414	0.4829	ME3	1.0101	1.2965	1.2193	1.0621	1.2583		
	0.02%	-0.0736	ME1	-4.0344	-2.2013	-1.7003	-1.3148	-1.1934	2.4688	ME1	4.1991	2.4601	2.0715	2.2143	2.4857
		ME2	0.4531	0.5178	0.5706	0.4320	0.3584	ME2	1.2043	1.2071	1.3152	1.8937	2.2829		
		ME3	0.4672	0.5320	0.6299	0.8471	0.9877	ME3	1.0770	1.3437	1.3165	1.2903	1.5195		
20-sec	0.005%	-0.2100	ME1	-15.9076	-8.5820	-6.5409	-4.6350	-3.8335	2.8522	ME1	15.9986	8.6873	6.6717	4.9348	4.3461
		ME2	-0.6112	-0.5503	-0.4999	-0.6579	-0.6963	ME2	1.4445	1.3178	1.3434	1.9301	2.2985		
		ME3	-0.5833	-0.5374	-0.4419	-0.2247	-0.0804	ME3	1.1720	1.4465	1.3753	1.0861	1.2128		
	0.01%	-0.1848	ME1	-14.3233	-7.7133	-5.8979	-4.1974	-3.4686	2.8539	ME1	14.4451	7.8232	6.0400	4.5338	4.0390
		ME2	-0.3499	-0.2930	-0.2487	-0.4073	-0.4497	ME2	1.3487	1.2193	1.2737	1.8768	2.2533		
		ME3	-0.3279	-0.2795	-0.1833	0.0347	0.1712	ME3	1.0570	1.3513	1.2855	1.0519	1.2480		
	0.02%	-0.1354	ME1	-11.3285	-6.1740	-4.6783	-3.3754	-2.8060	2.8581	ME1	11.4276	6.3005	4.8518	3.7987	3.5021
		ME2	0.1581	0.2138	0.2440	0.0920	0.0634	ME2	1.2626	1.1887	1.2912	1.8650	2.2347		
		ME3	0.1806	0.2296	0.3295	0.5495	0.6822	ME3	1.0035	1.3122	1.2790	1.1717	1.4295		

Notes: ME and RMSE are of the annualized standard deviation in percentage. MD3 is the two-factor stochastic volatility model with intraday volatility periodicity and the average true daily integrated volatility is around 36%. ME1 is the ACD-ICV method in Tse and Yang (2012). ME2 is ME1 with δ^2 replaced by V_D , the integrated volatility estimated using TRV with subsampling at 3-min sampling frequency. ME3 is ME2 with sampled durations computed from BTS returns. All ACD models are fitted to diurnally transformed durations using the time-transformation function based on the number of trades as in Tse and Dong (2014).

Table S12: ME and RMSE of daily volatility estimates of the RK and ACD-ICV methods for Model MD4

Sparsity	NSR	RK	ME					RK	ACD-ICV	RMSE						
			ACD-ICV	Avg. sampling frequency (ACD-ICV)						ACD-ICV	Avg. sampling frequency (ACD-ICV)					
				1-min	3-min	5-min	10-min				15-min	1-min	3-min	5-min	10-min	15-min
5-sec	0.005%	-0.1392	ME1	-4.3273	-2.7901	-2.1761	-1.4735	-1.0744	2.2287	ME1	4.6580	3.1543	2.6755	2.4237	2.5051	
		ME2	-0.0495	-0.0064	0.0371	0.1388	0.2862	ME2	1.5681	1.3739	1.4959	1.9008	2.2658			
		ME3	0.0241	0.0089	0.0718	0.2014	0.2764	ME3	1.0547	1.3115	1.3079	1.2890	1.3706			
	0.01%	-0.1186	ME1	-2.1935	-1.4121	-1.1154	-0.7545	-0.4749	2.2299	ME1	2.6423	1.9116	1.8335	2.0100	2.2642	
		ME2	0.2214	0.2643	0.2917	0.4040	0.5553	ME2	1.4576	1.2903	1.4621	1.8925	2.2714			
		ME3	0.2804	0.2694	0.3339	0.4596	0.5391	ME3	1.0469	1.2900	1.3068	1.3242	1.4129			
	0.02%	-0.0784	ME1	2.6623	1.2371	0.8316	0.5434	0.5493	2.2332	ME1	3.0175	1.6887	1.5544	1.8622	2.2316	
		ME2	0.7270	0.7673	0.8013	0.9268	1.0855	ME2	1.4677	1.3979	1.5569	2.0100	2.4160			
		ME3	0.7908	0.7864	0.8547	0.9708	1.0650	ME3	1.2255	1.4206	1.4601	1.5398	1.6284			
10-sec	0.005%	-0.1969	ME1	-8.3784	-4.9696	-3.8431	-2.6425	-2.0280	2.5340	ME1	8.6674	5.2711	4.2264	3.3330	3.0782	
		ME2	-0.1721	-0.1334	-0.1027	0.0030	0.1455	ME2	1.9351	1.5489	1.6187	1.9670	2.2838			
		ME3	-0.0688	-0.0957	-0.0495	0.0660	0.1438	ME3	1.1664	1.1820	1.2376	1.3347	1.4051			
	0.01%	-0.1737	ME1	-6.0018	-3.8539	-2.9829	-2.0536	-1.5586	2.5354	ME1	6.3235	4.1662	3.4131	2.8460	2.7661	
		ME2	0.1070	0.1400	0.1735	0.2746	0.4205	ME2	1.6517	1.4234	1.5607	1.9354	2.2908			
		ME3	0.1925	0.1621	0.2169	0.3401	0.4135	ME3	1.1288	1.1714	1.2203	1.3236	1.4153			
	0.02%	-0.1282	ME1	-2.6725	-1.6348	-1.3508	-0.9712	-0.6781	2.5382	ME1	3.1174	2.1176	2.0149	2.1226	2.3370	
		ME2	0.6470	0.6619	0.6871	0.8054	0.9596	ME2	1.6232	1.4529	1.6017	2.0189	2.4090			
		ME3	0.7104	0.6773	0.7394	0.8777	0.9437	ME3	1.2502	1.3162	1.3717	1.4739	1.6046			
20-sec	0.005%	-0.2998	ME1	-13.3204	-7.8200	-6.1131	-4.2413	-3.3202	2.9102	ME1	13.6066	8.1128	6.4488	4.7699	4.1023	
		ME2	-0.4123	-0.3825	-0.3583	-0.2556	-0.1106	ME2	2.3759	1.8500	1.8392	2.0798	2.3450			
		ME3	-0.2791	-0.3033	-0.2788	-0.1795	-0.1061	ME3	1.5569	1.2135	1.2524	1.3578	1.4859			
	0.01%	-0.2743	ME1	-11.3275	-6.8981	-5.4315	-3.7721	-2.9385	2.9106	ME1	11.6507	7.1867	5.7795	4.3379	3.7789	
		ME2	-0.1303	-0.1052	-0.0809	0.0211	0.1660	ME2	2.1932	1.6925	1.7505	2.0315	2.3168			
		ME3	-0.0116	-0.0343	-0.0073	0.0982	0.1684	ME3	1.4968	1.1375	1.1847	1.3111	1.4504			
	0.02%	-0.2249	ME1	-8.9181	-5.1741	-4.0973	-2.8888	-2.2279	2.9122	ME1	9.2785	5.4984	4.4887	3.5481	3.2275	
		ME2	0.3752	0.4125	0.4484	0.5575	0.7060	ME2	2.2374	1.6579	1.7088	2.0393	2.3828			
		ME3	0.5157	0.4939	0.5281	0.6425	0.7192	ME3	1.5317	1.1882	1.2484	1.3981	1.5441			

Notes: ME and RMSE are of the annualized standard deviation in percentage. MD4 is the deterministic volatility model with intraday volatility periodicity and the average true daily integrated volatility is around 28%. ME1 is the ACD-ICV method in Tse and Yang (2012). ME2 is ME1 with δ^2 replaced by V_D , the integrated volatility estimated using TRV with subsampling at 3-min sampling frequency. ME3 is ME2 with sampled durations computed from BTS returns. All ACD models are fitted to diurnally transformed durations using the time-transformation function based on the number of trades as in Tse and Dong (2014).

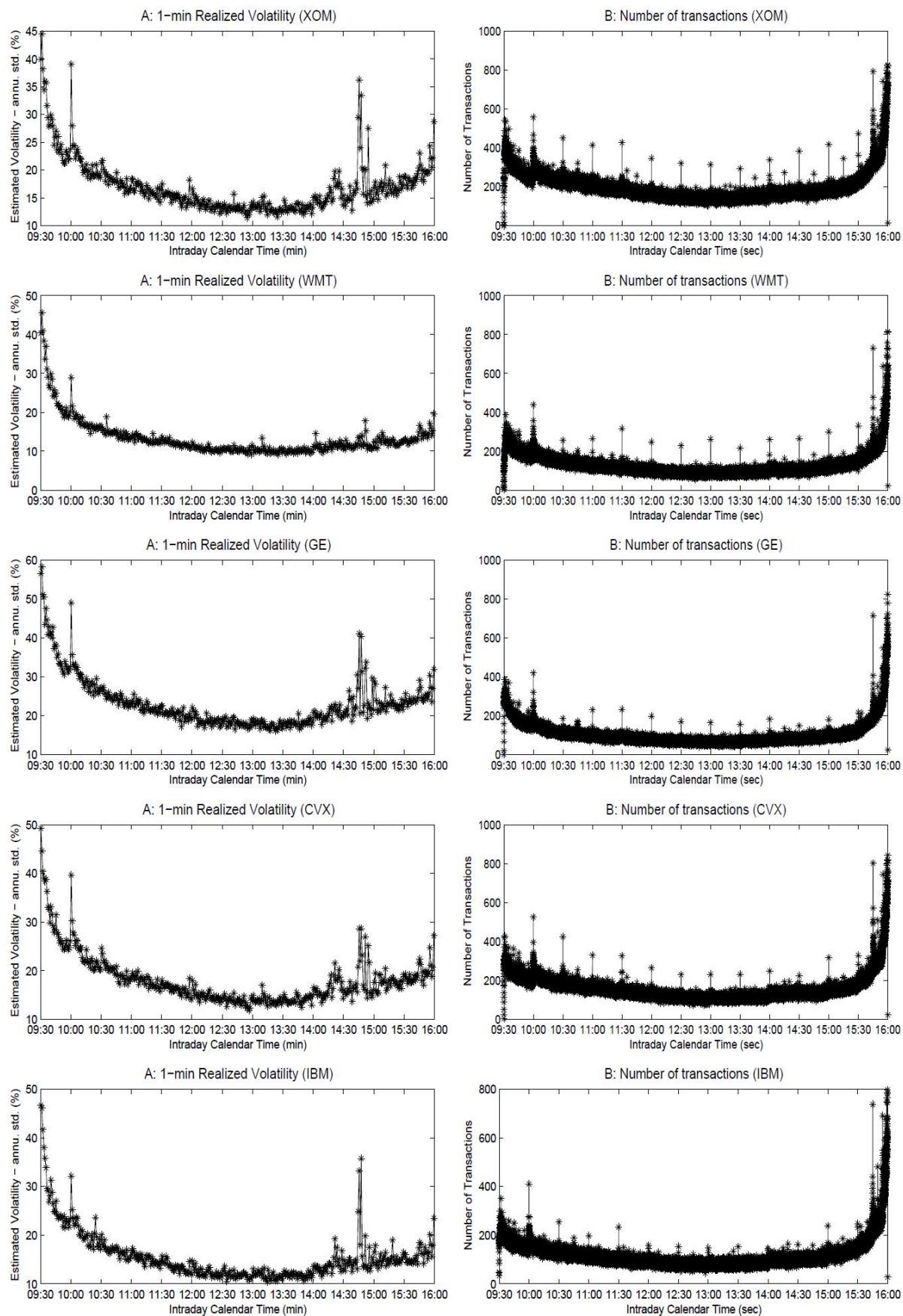


Figure S.1: 1-min Realized Volatility and number of transactions, 2010-2013.

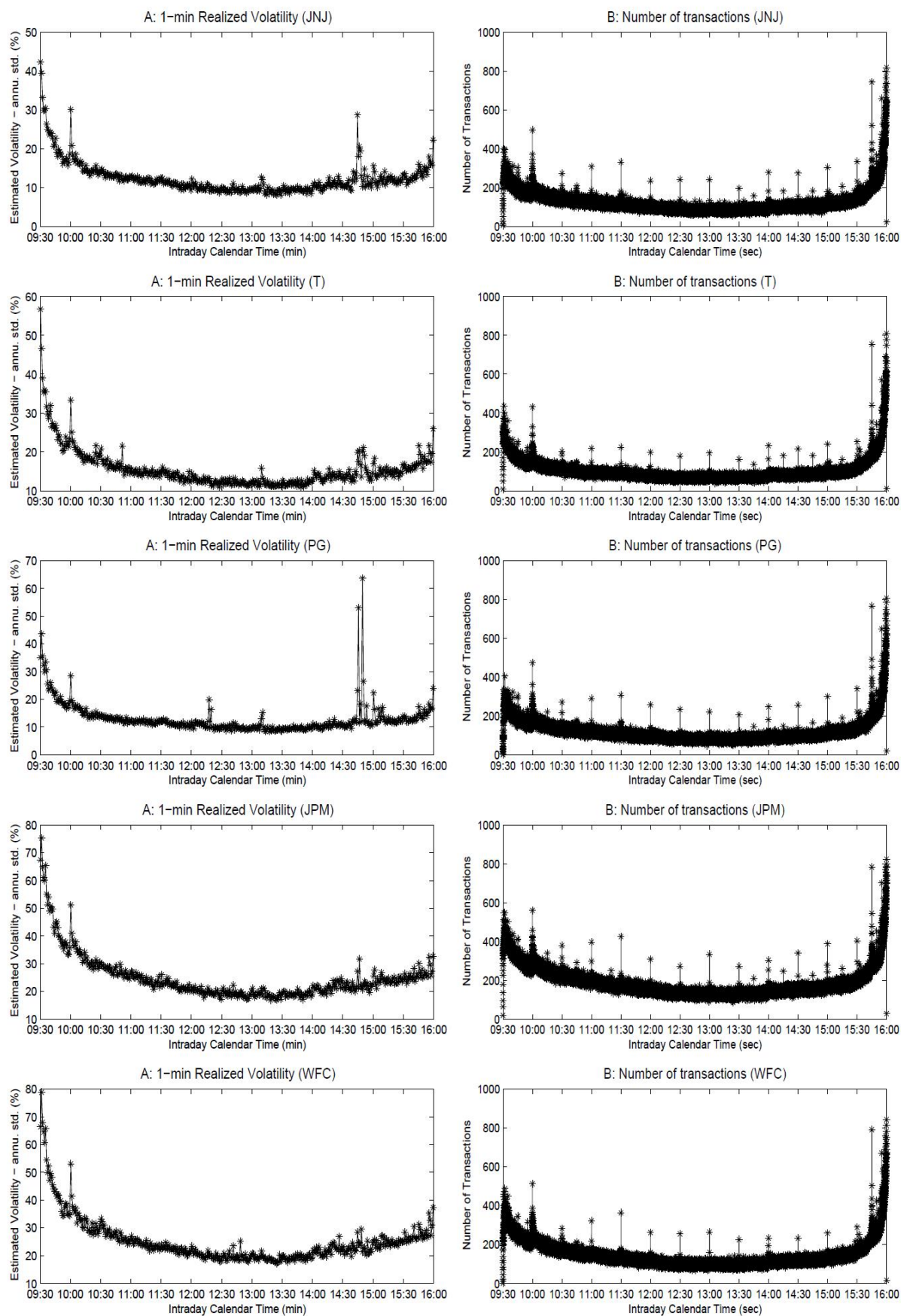


Figure S.1 (continued): 1-min Realized Volatility and number of transactions, 2010-2013.

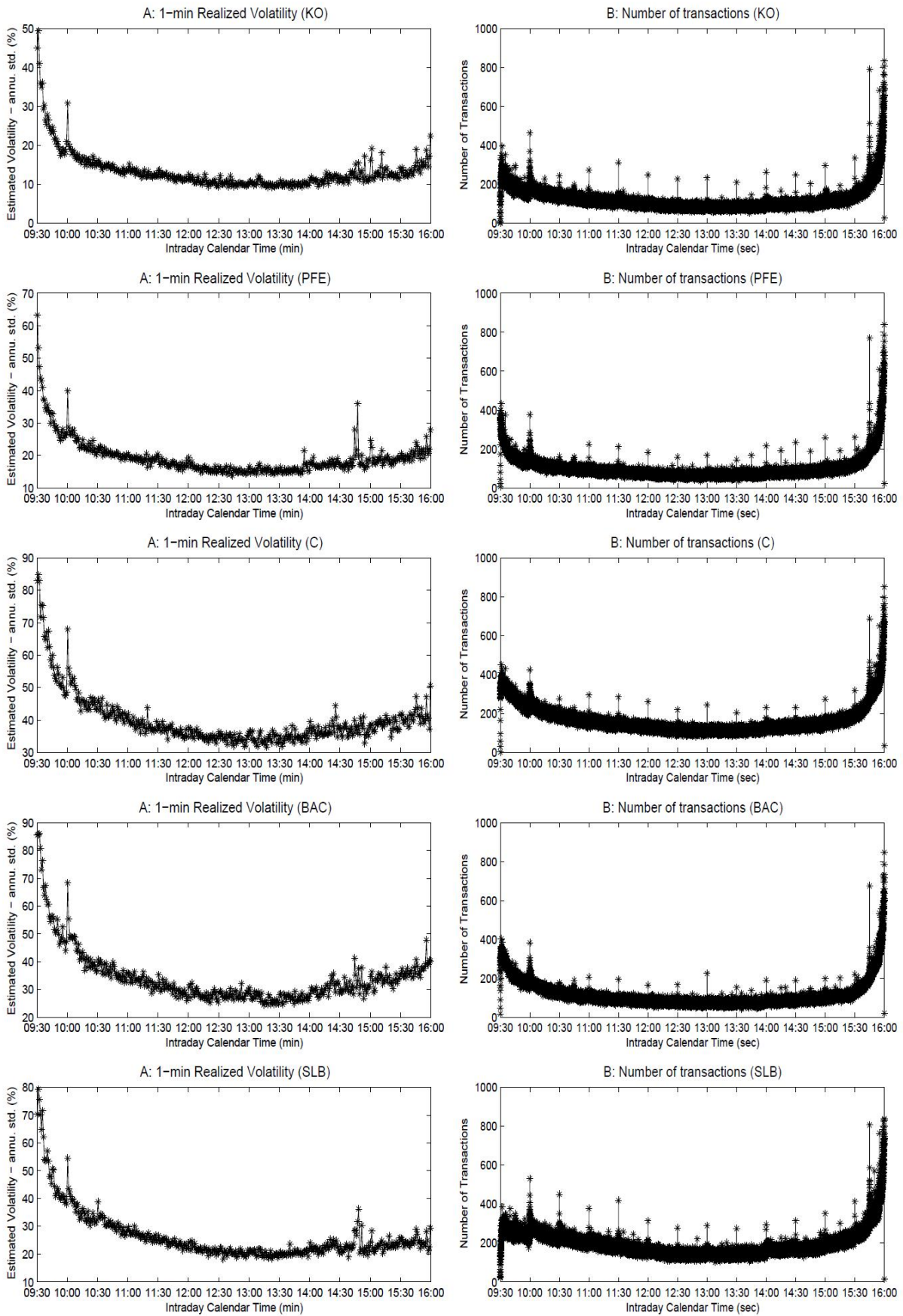


Figure S.1 (continued): 1-min Realized Volatility and number of transactions, 2010-2013.

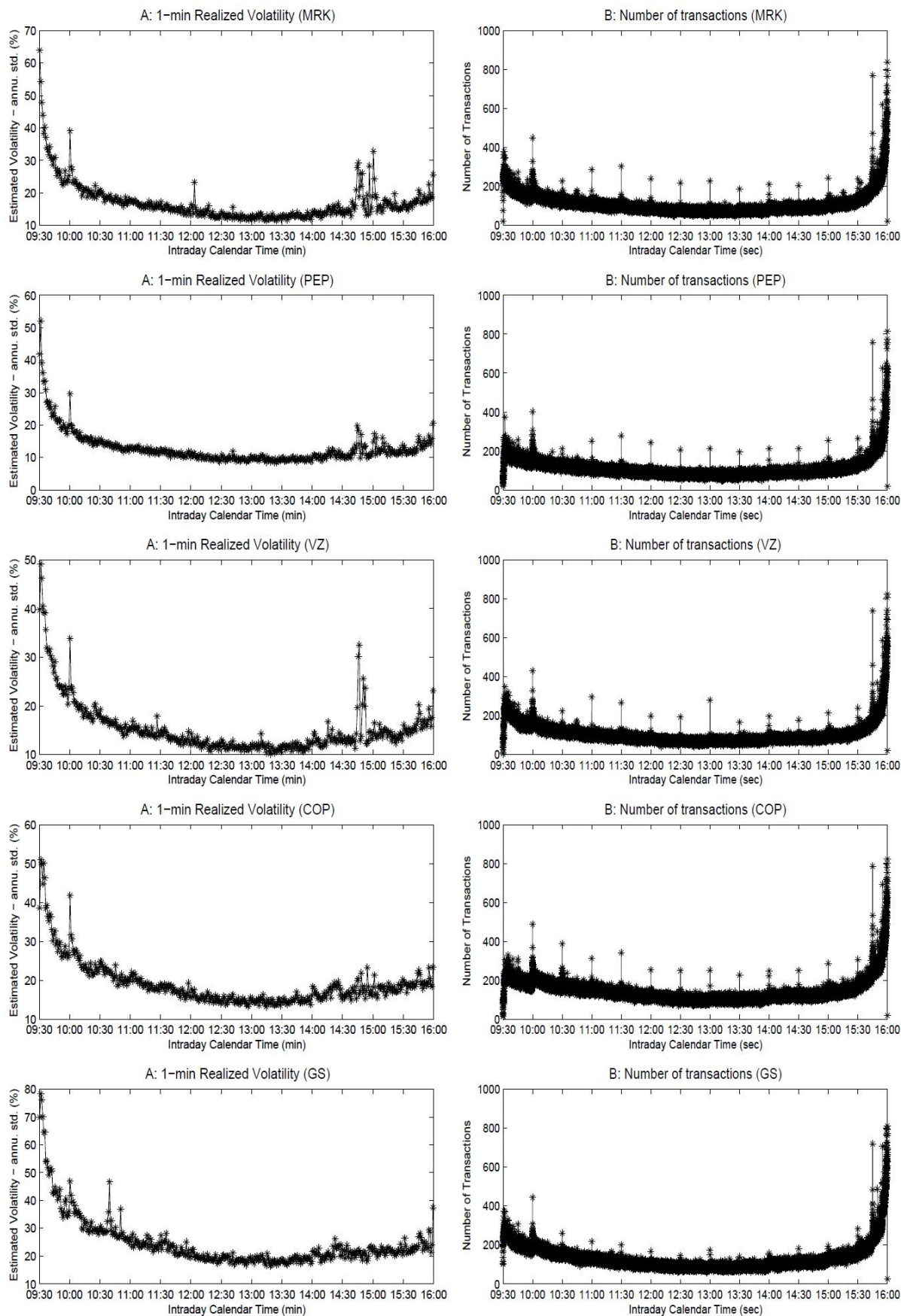


Figure S.1 (continued): 1-min Realized Volatility and number of transactions, 2010-2013.

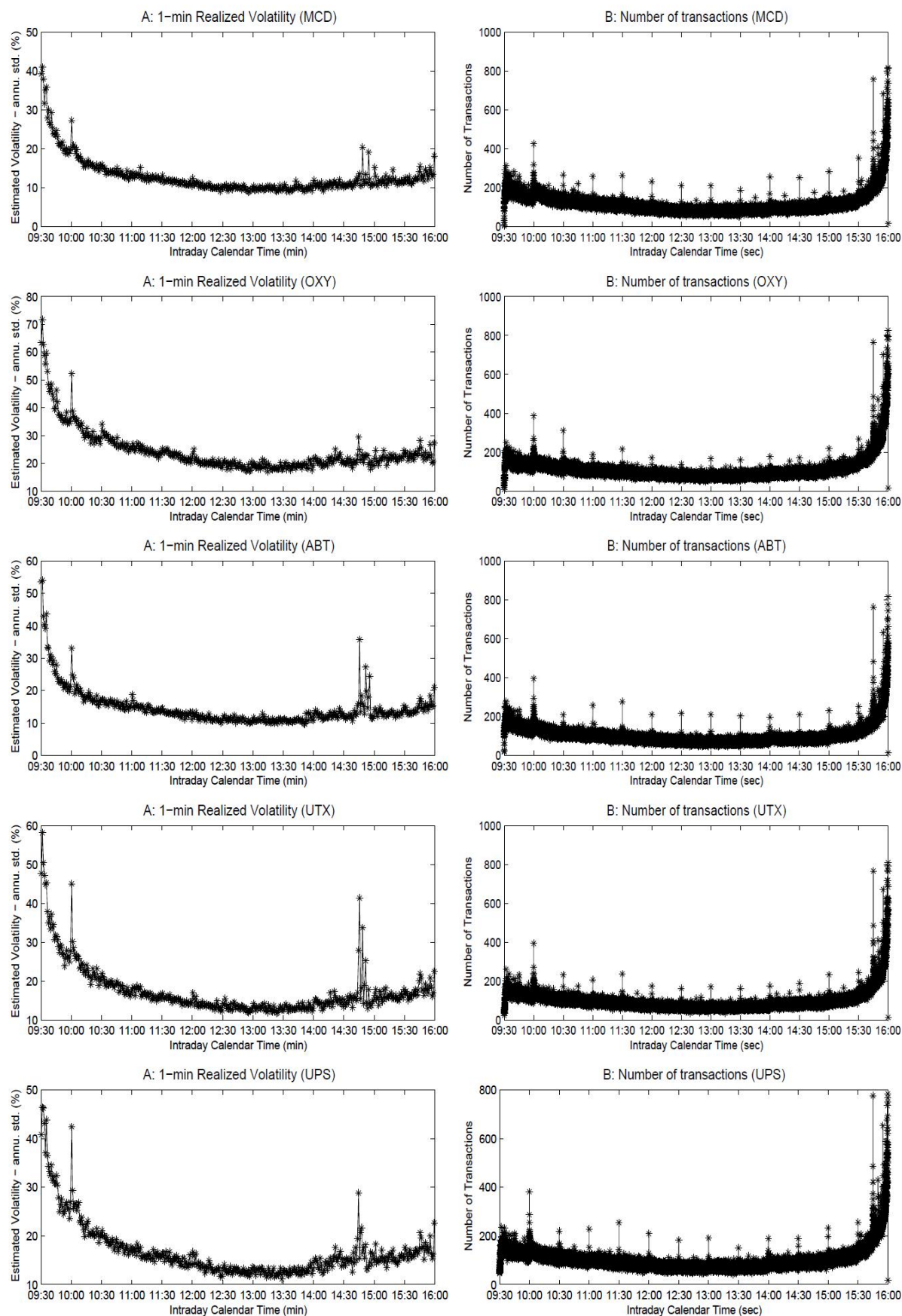


Figure S.1 (continued): 1-min Realized Volatility and number of transactions, 2010-2013.

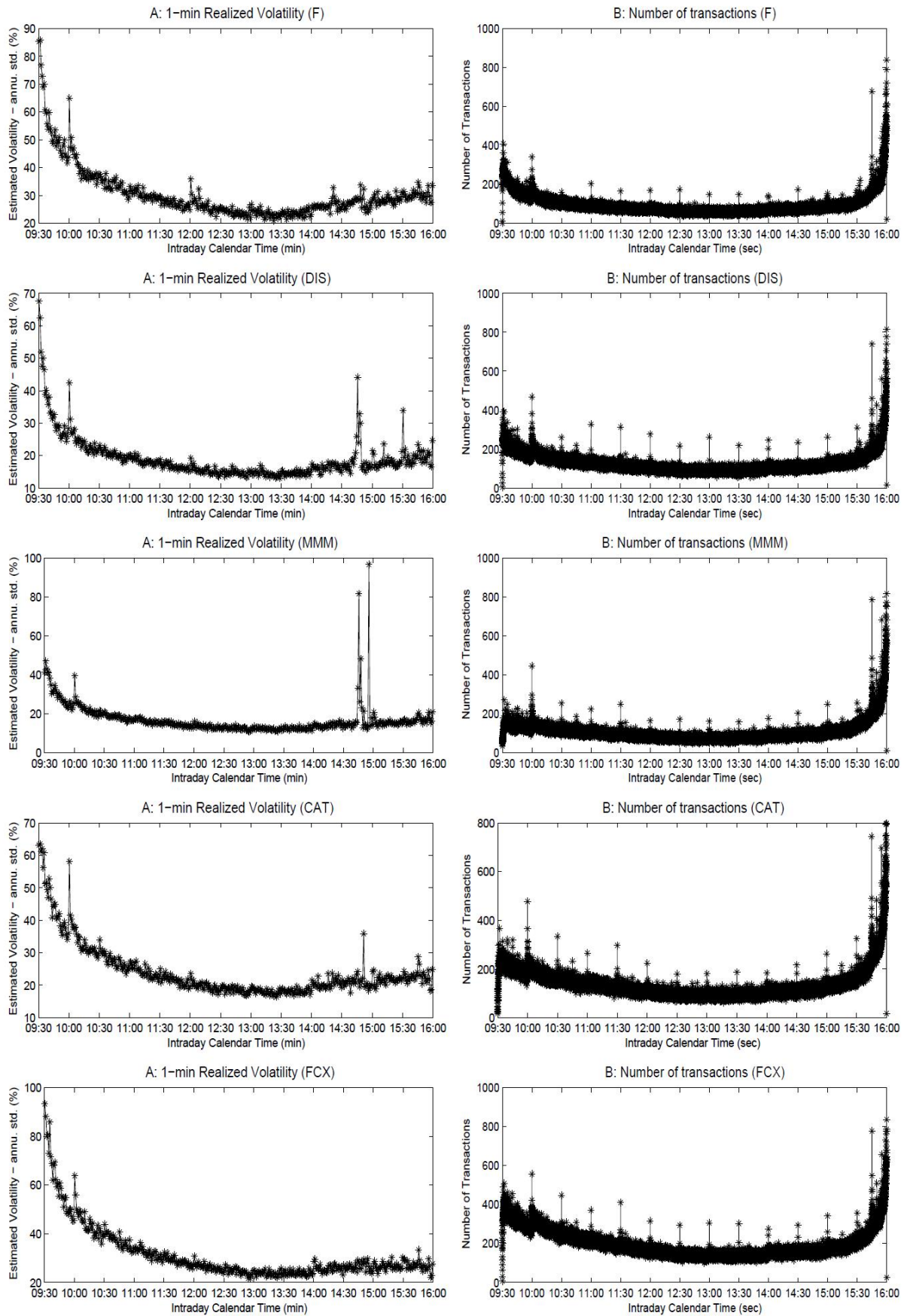


Figure S.1 (continued): 1-min Realized Volatility and number of transactions, 2010-2013.

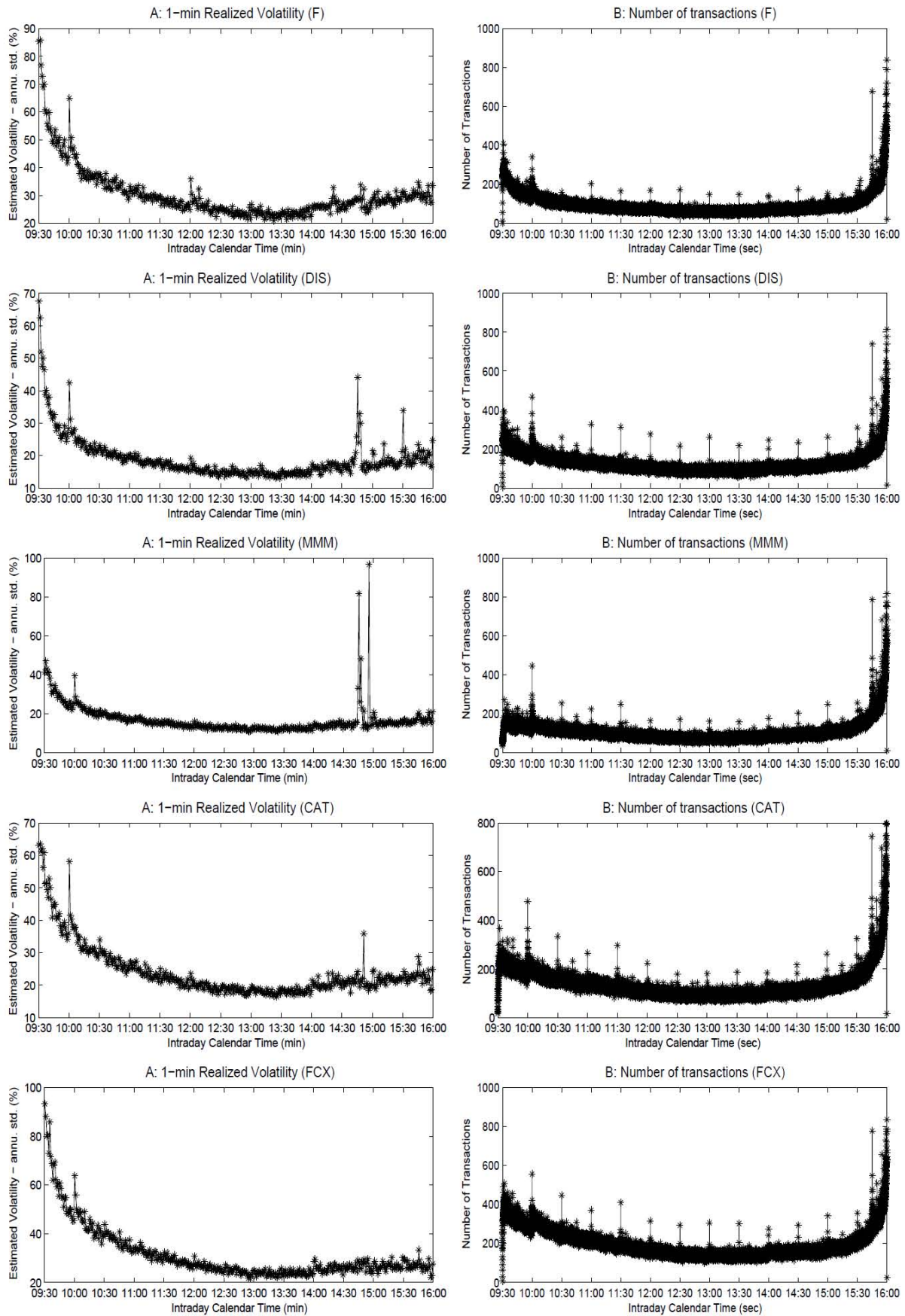


Figure S.1 (continued): 1-min Realized Volatility and number of transactions, 2010-2013.

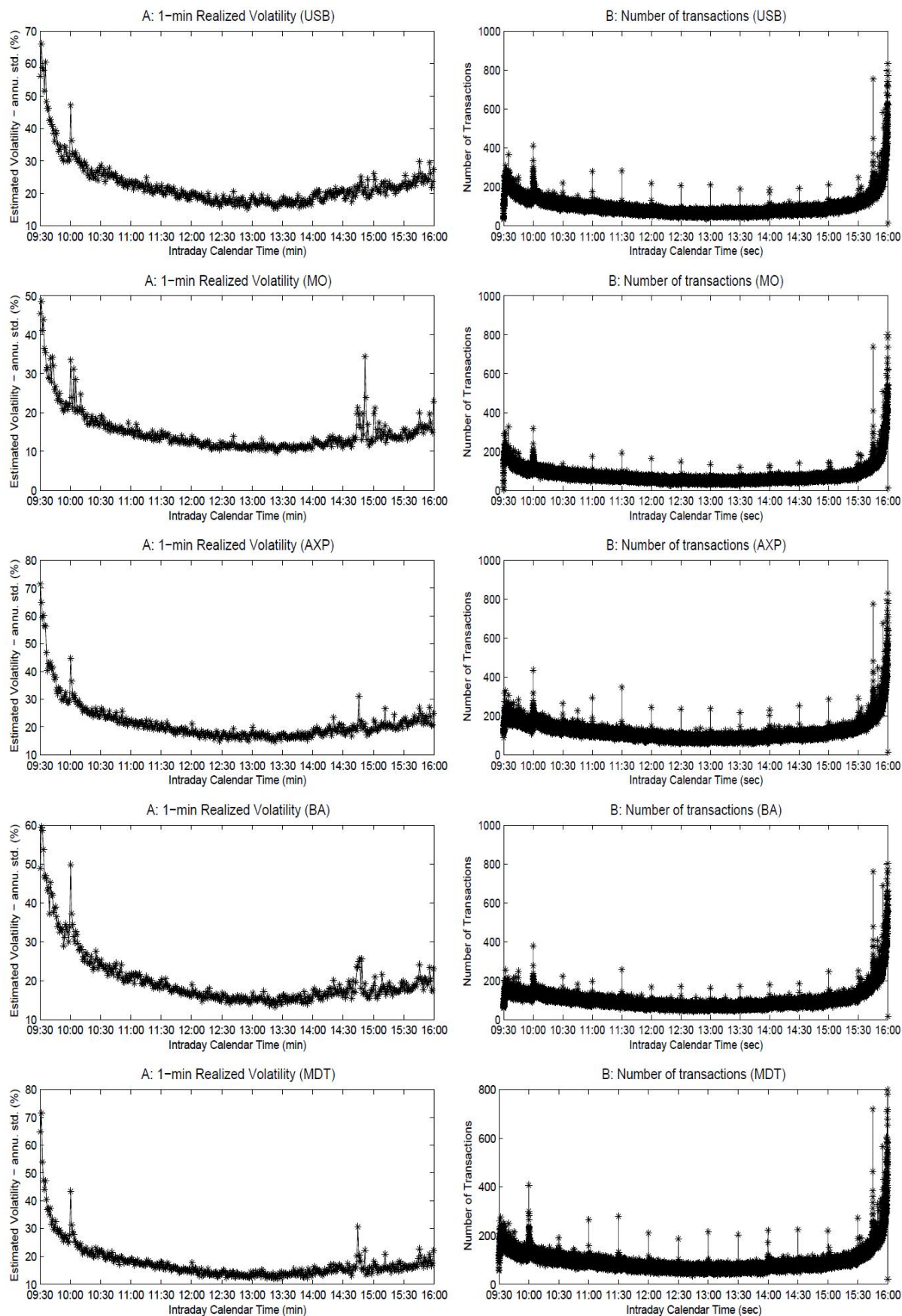


Figure S.1 (continued): 1-min Realized Volatility and number of transactions, 2010-2013.

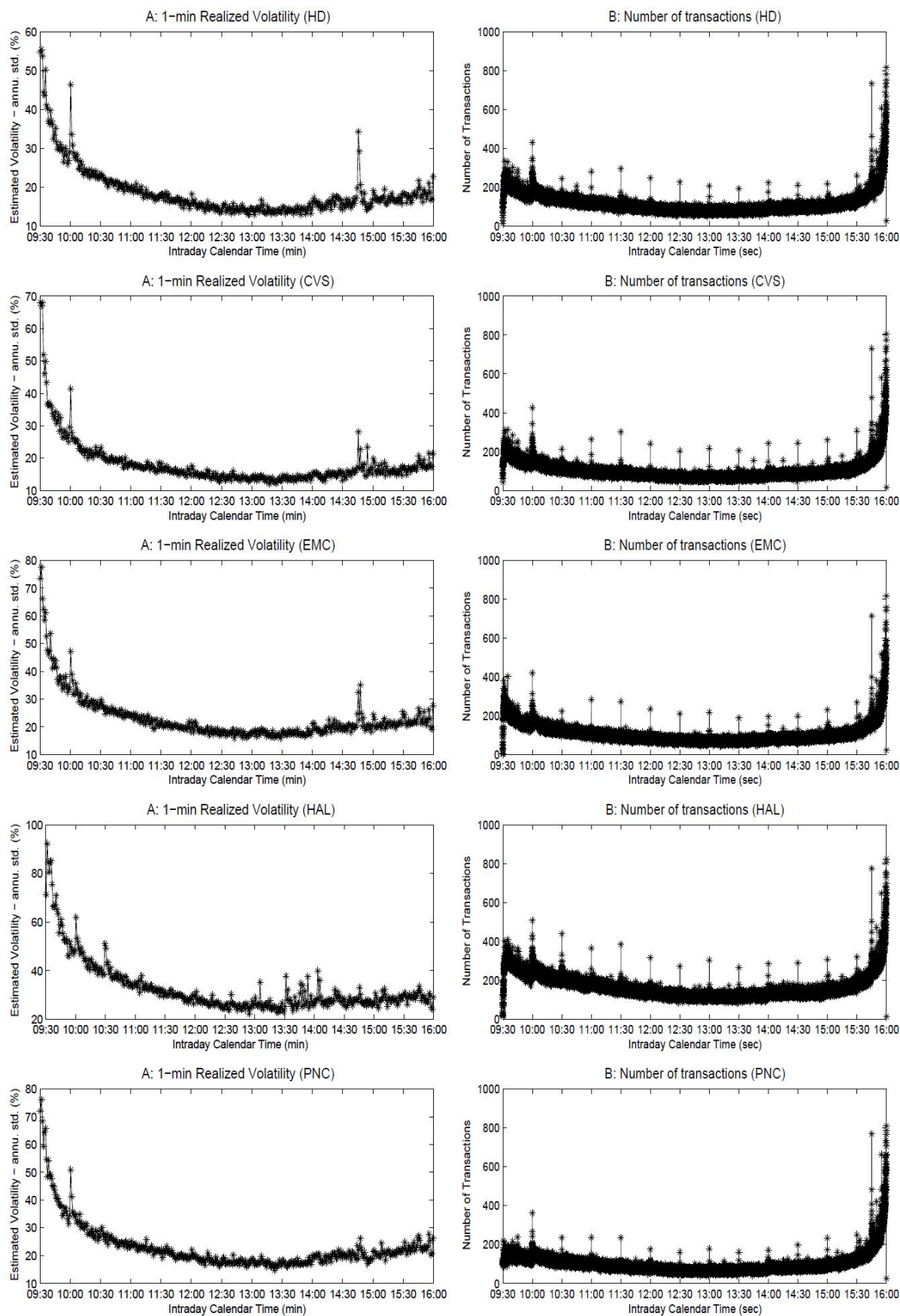


Figure S.1 (continued): 1-min Realized Volatility and number of transactions, 2010-2013.