June 26, 2024 - cascad#351

Execution Report

Title: **Efficient Estimation of Bid-Ask Spreads from Open, High, Low, and Close Prices**

Authors: **David Ardia, Emanuele Guidotti, Tim A. Kroencke**

Full reference: Ardia, David, Guidotti, Emanuele and Kroencke, Tim "Efficient estimation of Bid-Ask Spreads from Open, Low and Close prices", working paper, June 22, 2024.

The structure and contents of this execution report provided by **cascad** for the certification are similar to those recommended by the AEA Data Editor.

1. DATA DESCRIPTION

This study relies on three sources of data:

- Historical cryptocurrency data from Binance Market Data up to February 2023;
- The Center for Research in Security Prices (CRSP) U.S. Stock Database;
- The NYSE Trade and Quote database.

They are used to evaluate the efficiency of new asymptotically unbiased estimators for the effective bid-ask spread.

For a thorough description of the data, please refer to section 4.1 of the paper.

2. CODE DESCRIPTION

The verification materials contain the following files and subfolders:

Files:

- edge.Rproj
- renv.lock
- main.R

Folders:

- data/
- input/
- output/
- renv/
- scripts/

- *data* is supposed to store the raw data files and several R and SAS script that clean, process and combine them into analysis datasets. Since most of the data is proprietary and cannot be shared, only the scripts are provided.

- *input* contains the pre-processed datasets.

- *output* and *scripts* are self-explanatory.

- The *renv* folder and the *renv.lock* file are used by a R package of the same name. It allows one to recreate the environment the researchers used. Once this package is installed, running *renv::restore()* in R will install all packages mentioned in the lockfile, using the same version and source as the authors'.

main.R is the Masterfile: once the environment is set up, running this script will generate all the results.

3. VERIFICATION STEPS

The verification package was downloaded from the **cascad** website on June 24 and run as per readme, using R 4.4.0 on a computer with 512 GB RAM, Intel Xeon Silver 4216R 2.10GHz (32 cores), NVIDIA RTX™ A5000 and Windows 10 OS. **Because we were unable to access the proprietary data, we used the authors' pre-processed datasets**.

We experienced some minor versioning issues. Initially, the R environment the researchers used did not work in R 4.4.0 (they used R 4.2.3). When we tried installing all dependencies with the *renv::restore()* command, we received the following error message:

```
installing to C:/Users/[redacted]/Dropbox (HEC PARIS)/cascad Working Files/Certifications/Site cascad/351/cascad/renv/staging/1/00LOCK-jsonlite/00new/jsonlite/libs/x64
** R
** inst
** byte-compile and prepare package for lazy loading
Error in .make_numeric_version(x, strict, .standard_regexps()$valid_numeric_version) :
  invalid non-character version specification 'x' (type: double)
Erreur : impossible de charger le code R depuis le package 'jsonlite'
Exécution arrêtée
ERROR: lazy loading failed for package 'jsonlite'
* removing 'C:/Users/[redacted]/Dropbox (HEC PARIS)/cascad Working Files/Certifications/Site cascad/351/cascad/renv/staging/1/jsonlite'
install of package 'jsonlite' failed [error code 1]
```

We also received a similar message for the ggplot2 package. To bypass this issue, we edited *renv.lock* so that it installs the most recent versions of those packages: that is, 1.8.8 for *jsonlite* and 3.5.1 for *ggplot2*. *renv* also automatically updated the *scales* package, whose requested version would not work with newer versions of *ggplot2*:

```
Installation of 'scales 1.2.1' was requested, but the following constraints are not met:

- ggplot2 (requires scales >= 1.3.0)

renv will try to install 'scales 1.3.0' instead.
```

Once this was done, the code ran without any issue.

4. FINDINGS

Using the researchers' pre-processed data, we reproduced Tables 2-4, I.2, and I4-I.9 and Figures 1-8 and I.2 with accuracy.
Tables 1 and I.1 and Figure I.1 do not contain numerical results and are therefore outside the scope of this verification. Table I.3 is not mentioned in the readme file and is also outside the scope of this verification.

4.1 TABLE 2: MONTHLY ESTIMATES FROM SIMULATED DAILY PRICES

PANEL A

SPREAD	TYPE	EDGE	OHLC	CHLO	OHL	CHL	AR	CS	ROLL
0.50	Mean	0.44	0.46	0.46	0.79	0.79	0.70	0.60	1.44
0.50	Sd	0.33	0.40	0.39	0.79	0.79	0.77	0.49	1.43
1.00	Mean	0.90	0.88	0.88	1.03	1.03	0.95	1.03	1.59
1.00	Sd	0.42	0.55	0.55	0.86	0.86	0.85	0.58	1.49
3.00	Mean	2.88	2.87	2.88	2.92	2.93	2.92	2.93	2.95
3.00	Sd	0.41	0.69	0.69	0.73	0.72	0.70	0.61	1.83
5.00	Mean	4.87	4.86	4.87	4.92	4.93	4.97	4.90	4.90
5.00	Sd	0.42	0.81	0.81	0.62	0.62	0.58	0.61	2.14
8.00	Mean	7.84	7.78	7.79	7.88	7.89	7.99	7.86	7.93
8.00	Sd	0.45	1.11	1.10	0.64	0.64	0.54	0.62	2.63

PANEL B

SPREAD	TYPE	EDGE	OHLC	CHLO	OHL	CHL	AR	CS	ROLL
0.50	Mean	0.71	0.77	0.79	0.89	0.91	0.65	0.02	1.44
0.50	Sd	0.75	0.87	0.88	0.96	0.97	0.73	0.07	1.42
1.00	Mean	0.95	0.99	0.99	1.11	1.10	0.81	0.04	1.56
1.00	Sd	0.83	0.97	0.96	1.03	1.04	0.80	0.10	1.47
3.00	Mean	2.89	2.76	2.76	2.86	2.86	2.26	0.35	2.89
3.00	Sd	0.83	1.23	1.23	1.20	1.19	0.92	0.36	1.82
5.00	Mean	5.02	4.89	4.92	5.01	5.04	4.04	1.17	4.83
5.00	Sd	0.81	1.32	1.33	1.13	1.13	0.85	0.62	2.12
8.00	Mean	8.19	8.10	8.06	8.23	8.20	6.59	2.66	7.71
8.00	Sd	0.96	1.59	1.62	1.24	1.26	0.94	0.96	2.65

4.2. TABLE 3: SUMMARY STATISTICS

ESTIMATOR	N	MEAN	MEDIAN	SD	COR1	COR2	MAPE	RMSE	ZERO
AR	1637621	1.70	0.95	2.50	68.13	53.55	19.90	1.41	31.87
CHL	1637621	2.16	1.03	3.67	73.83	55.44	18.93	1.41	31.30
CHLO	1637621	2.01	0.85	3.56	74.26	58.77	17.08	1.27	30.97
CS	1637621	0.66	0.28	1.10	45.55	33.77	35.90	2.61	29.18
EDGE	1637621	2.11	1.00	3.37	78.86	66.68	16.21	1.23	25.63
HJ	1637621	1.89	0.75	2.73	100.00	100.00	0.00	0.00	0.00
OHL	1637621	2.35	1.21	3.65	69.95	54.64	20.47	1.49	29.97
OHLC	1637621	2.22	1.05	3.57	69.87	57.17	18.83	1.37	29.74
ROLL	1637621	2.47	1.39	4.09	55.22	41.38	24.53	1.80	32.60

4.3. TABLE 4: PEARSON'S CORRELATION WITH THE HJ BENCHMARK

Panel A:

EXCHCD	EDGE	OHLC	CHLO	OHL	CHL	AR	CS	ROLL
1	**64.94**	53.22	61.84	52.15	58.43	46.79	45.87	29.59
2	**68.99**	57.77	67.84	59.26	68.23	61.05	38.32	48.15
3	**78.16**	68.62	73.24	68.87	72.99	67.03	41.09	54.81

Panel B:

PERIOD	EDGE	OHLC	CHLO	OHL	CHL	AR	CS	ROLL
1	**82.93**	75.94	76.83	77.68	78.57	75.31	46.94	70.23
2	**78.47**	68.24	73.40	68.95	73.41	69.20	45.06	60.19
3	**73.04**	60.47	70.32	61.44	69.59	67.31	40.70	59.00
4	**67.65**	57.56	63.45	57.26	61.97	57.34	33.87	38.10
5	**69.89**	62.16	64.00	61.49	62.26	59.17	33.99	43.70
6	**60.78**	51.41	55.93	52.09	55.64	53.14	37.29	29.24
7	**53.98**	46.72	43.97	46.48	43.11	40.78	39.34	22.11

Panel C:

TCAP5	EDGE	OHLC	CHLO	OHL	CHL	AR	CS	ROLL
1	**74.35**	63.60	69.90	64.86	70.44	65.00	37.16	56.08
2	**71.29**	60.36	66.68	60.39	66.33	56.08	30.20	44.31
3	**75.13**	65.09	70.32	63.12	67.28	57.22	38.41	40.11
4	**72.55**	62.93	68.07	59.63	63.44	53.02	44.60	32.90
5	**66.65**	57.77	61.32	54.24	56.17	47.31	47.24	30.31

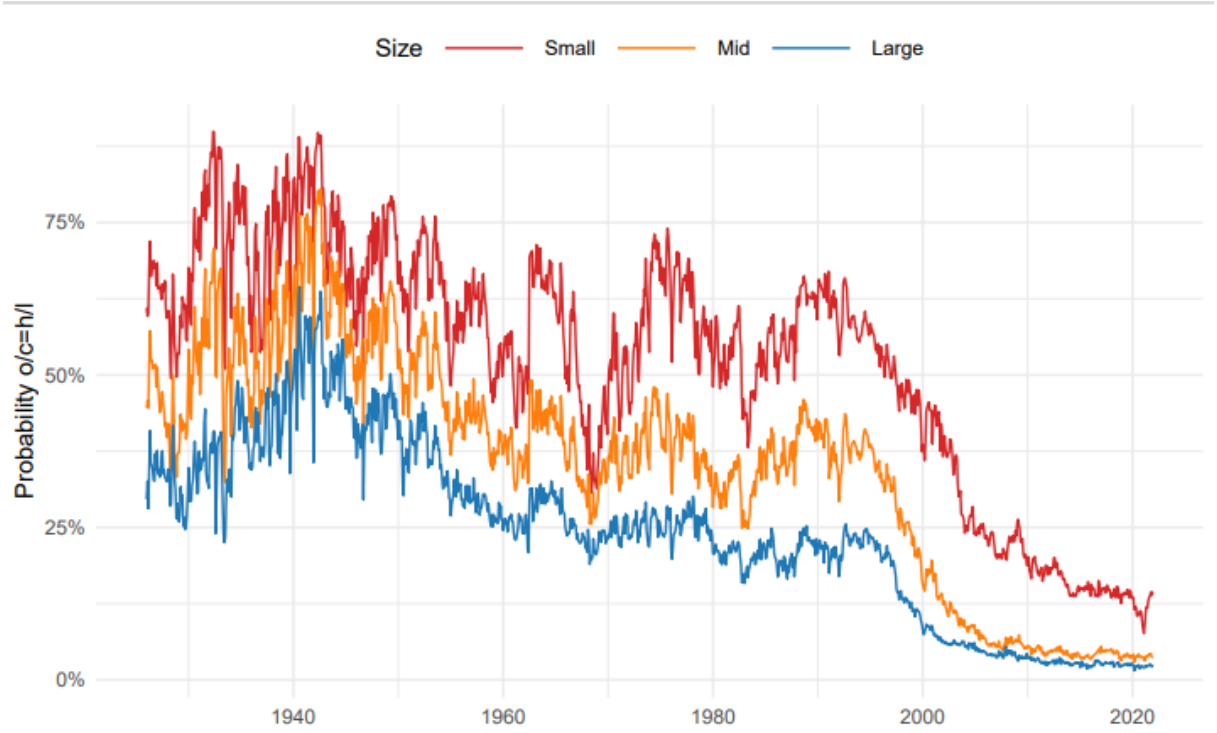
Panel D:

SPREAD5	EDGE	OHLC	CHLO	OHL	CHL	AR	CS	ROLL
1	**17.84**	15.62	16.56	15.43	15.21	14.18	12.64	9.60
2	**45.66**	39.59	41.73	34.67	34.15	30.35	32.79	15.06
3	**61.98**	52.28	57.80	48.88	52.46	44.72	40.82	24.64
4	**67.76**	55.55	64.44	55.32	63.21	55.22	37.74	38.98
5	**71.38**	60.78	66.08	62.57	67.24	61.83	33.15	55.06

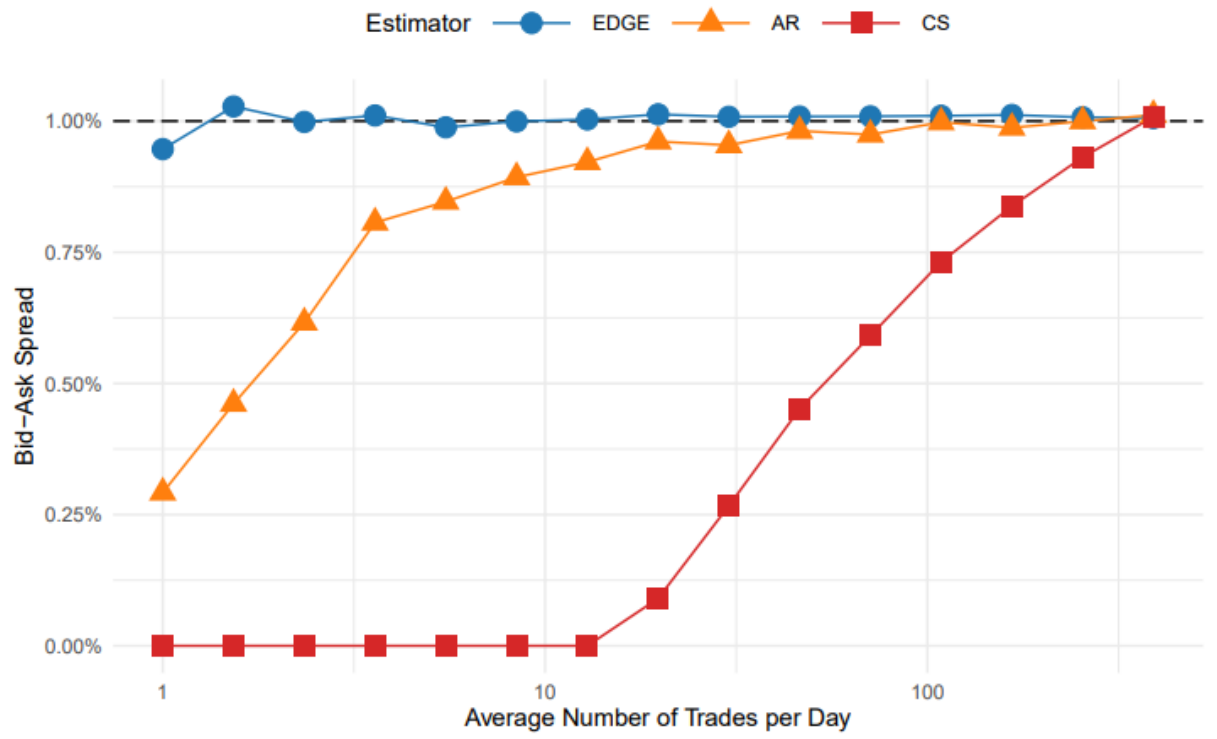
Panel E:

NUMTRD5	EDGE	OHLC	CHLO	OHL	CHL	AR	CS	ROLL
1	**74.77**	65.88	69.12	67.68	70.37	67.81	40.02	65.10
2	**79.15**	69.32	74.45	69.55	74.17	69.58	51.59	52.00
3	**75.41**	65.77	70.94	63.92	67.92	60.98	50.42	40.53
4	**67.17**	58.53	62.78	56.00	58.71	52.54	48.98	32.41
5	**55.48**	48.05	50.02	45.23	45.78	39.36	43.91	22.29

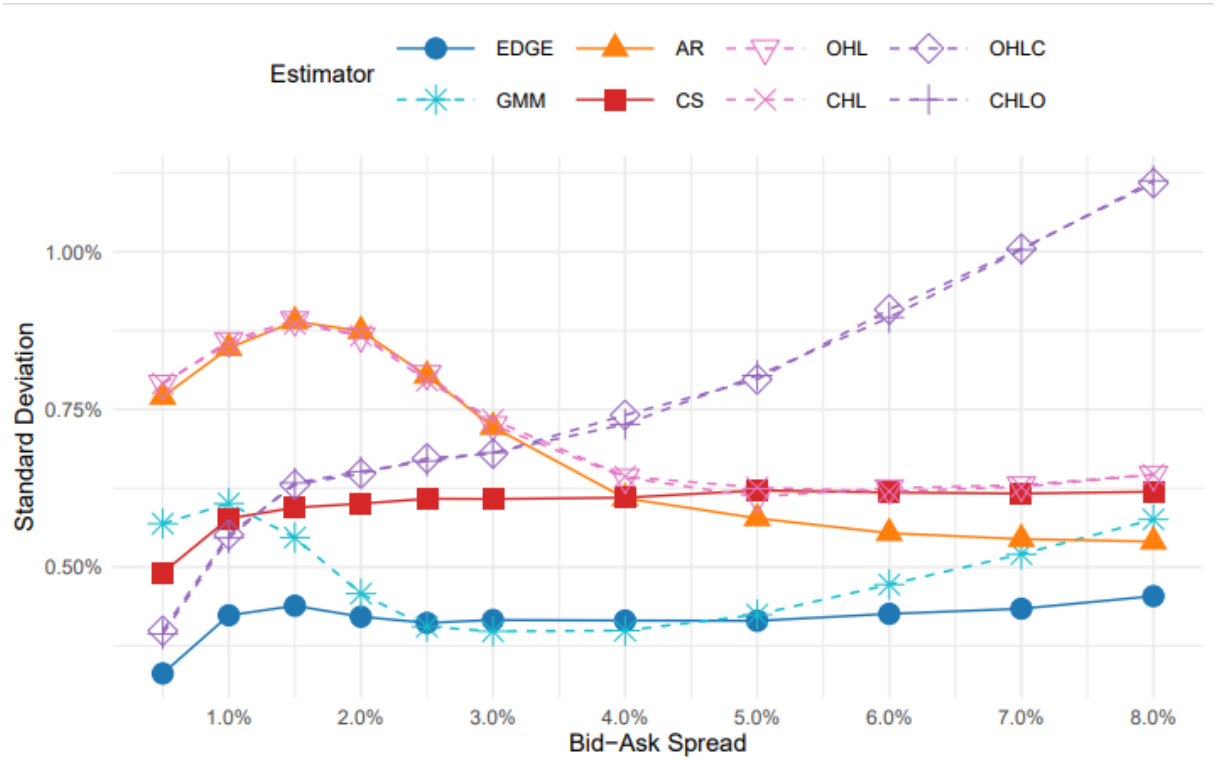
4.4. FIGURE 1: PROBABILITY THAT OPEN/CLOSE PRICES ARE HIGH/LOW PRICES



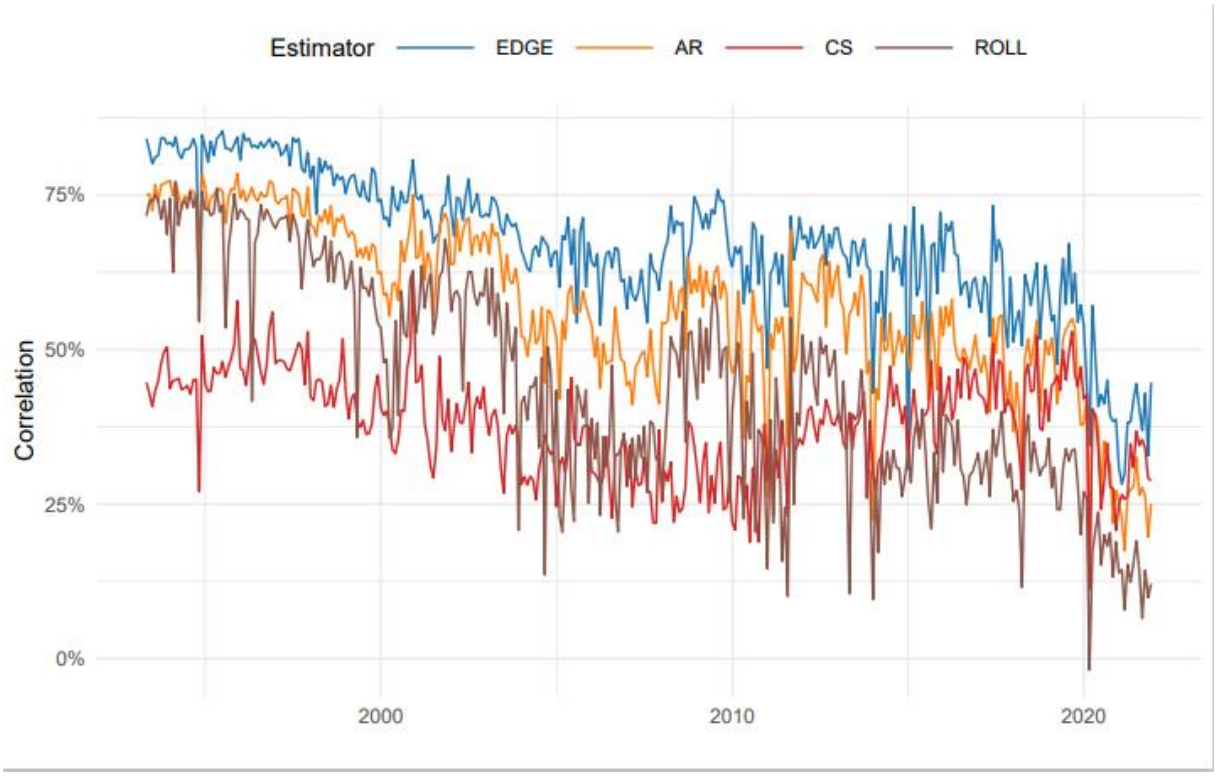
4.5. FIGURE 2: BIAS OF SIMULATED SPREAD ESTIMATES



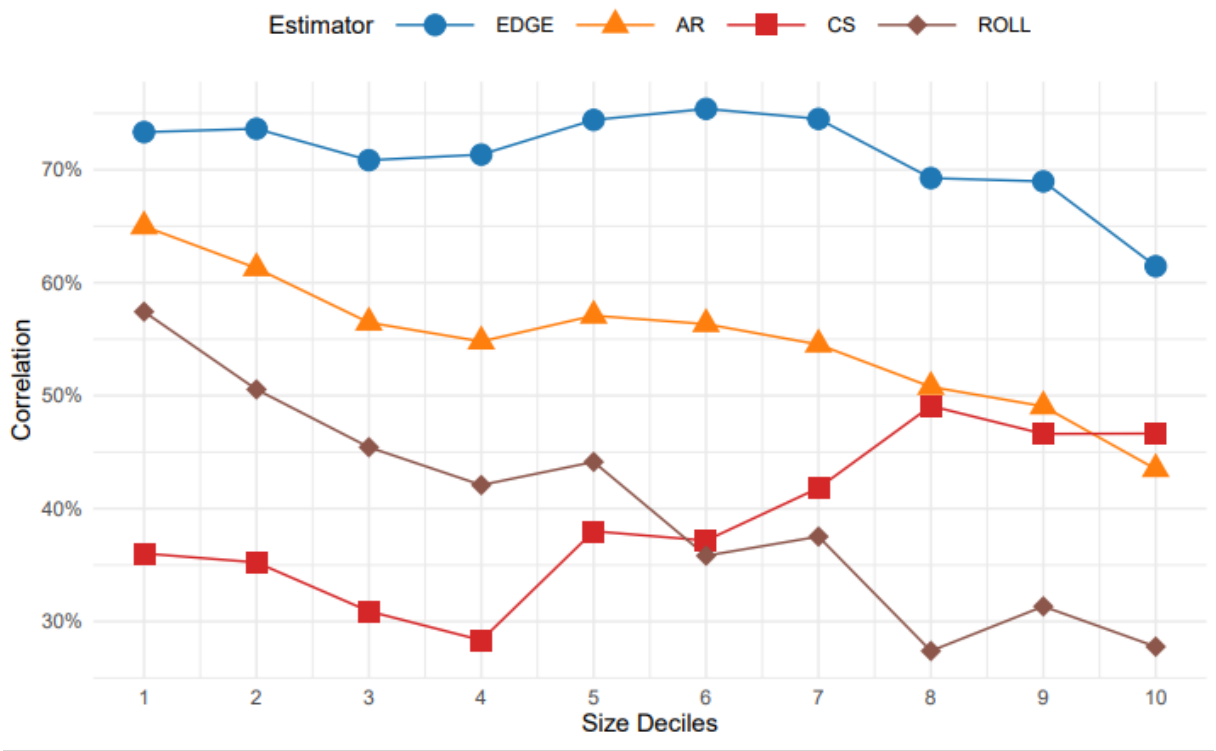
4.6. FIGURE 3: VARIANCE OF SIMULATED SPREAD ESTIMATES



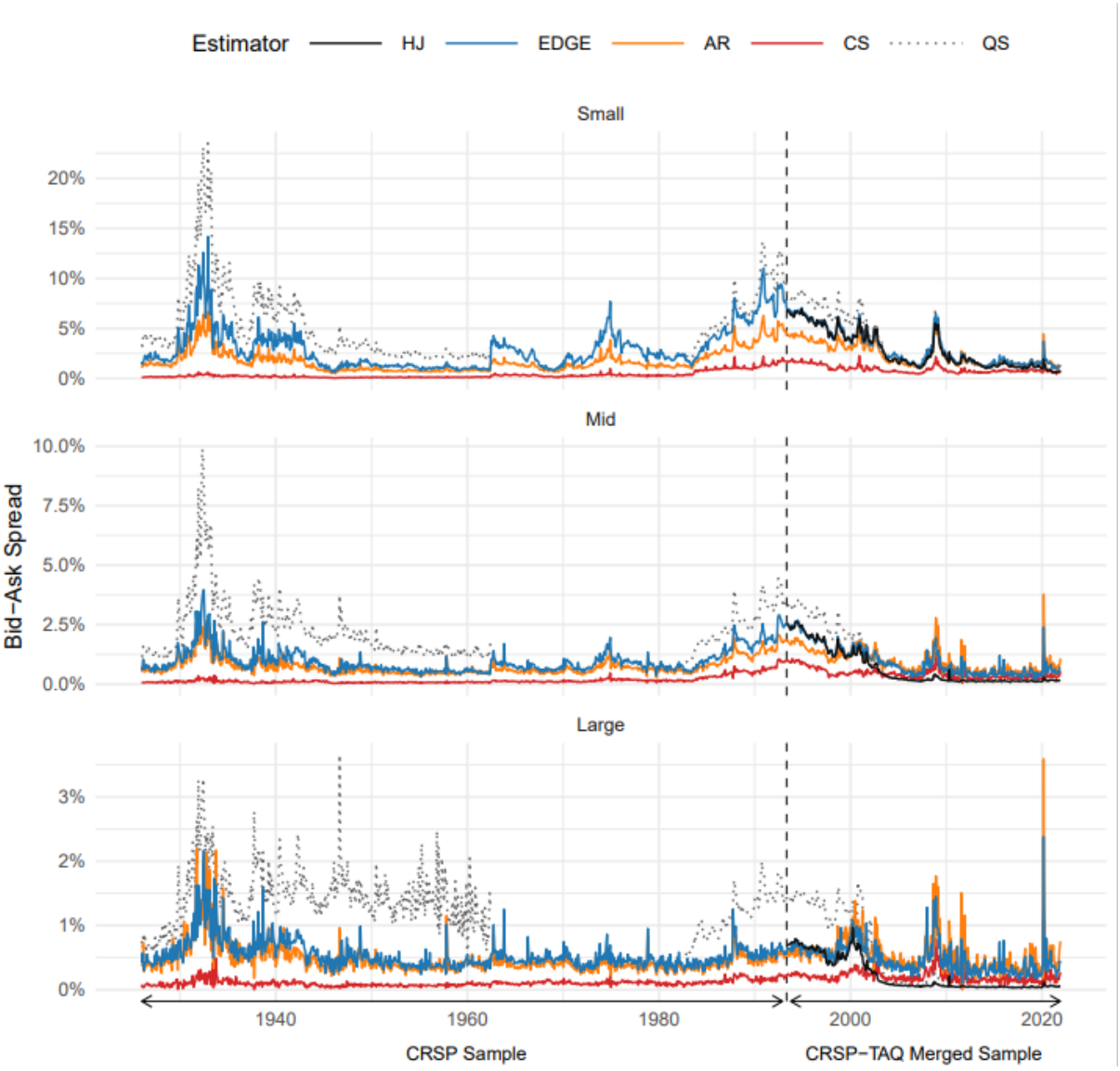
4.7. FIGURE 4: CROSS-SECTIONAL CORRELATION WITH THE HJ BENCHMARK



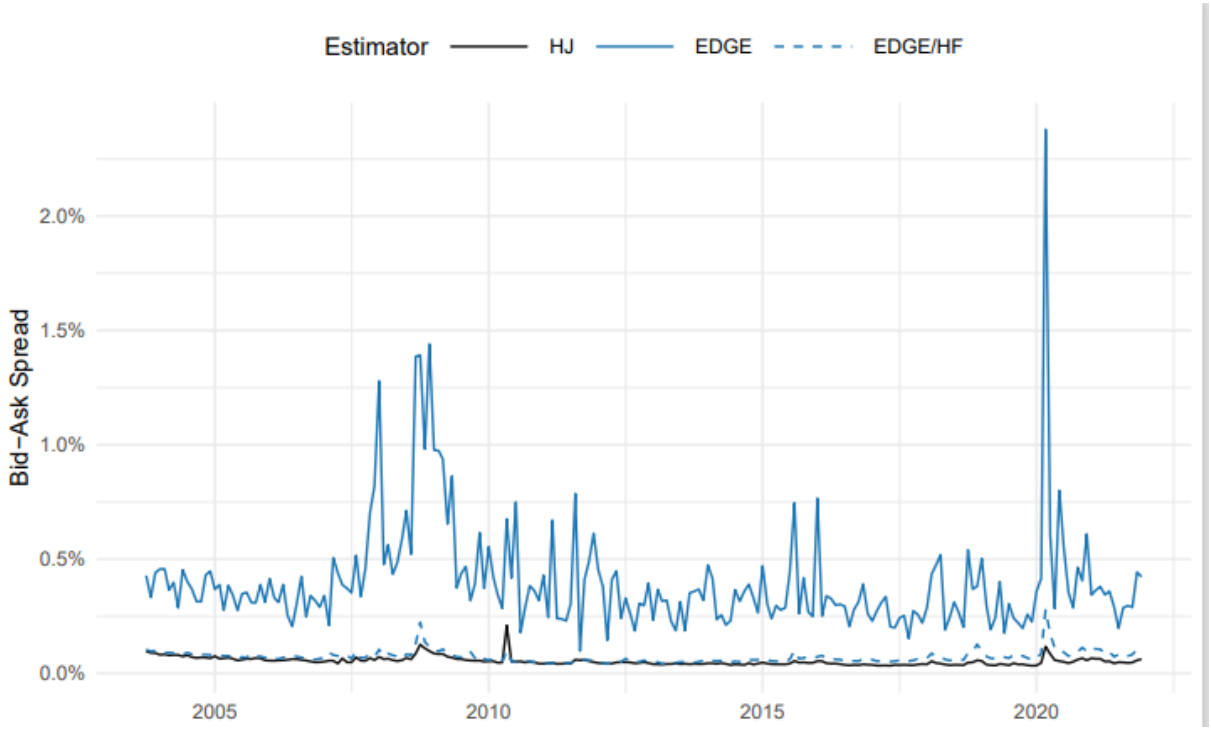
4.8. FIGURE 5: TIME-SERIES CORRELATION WITH THE HJ BENCHMARK



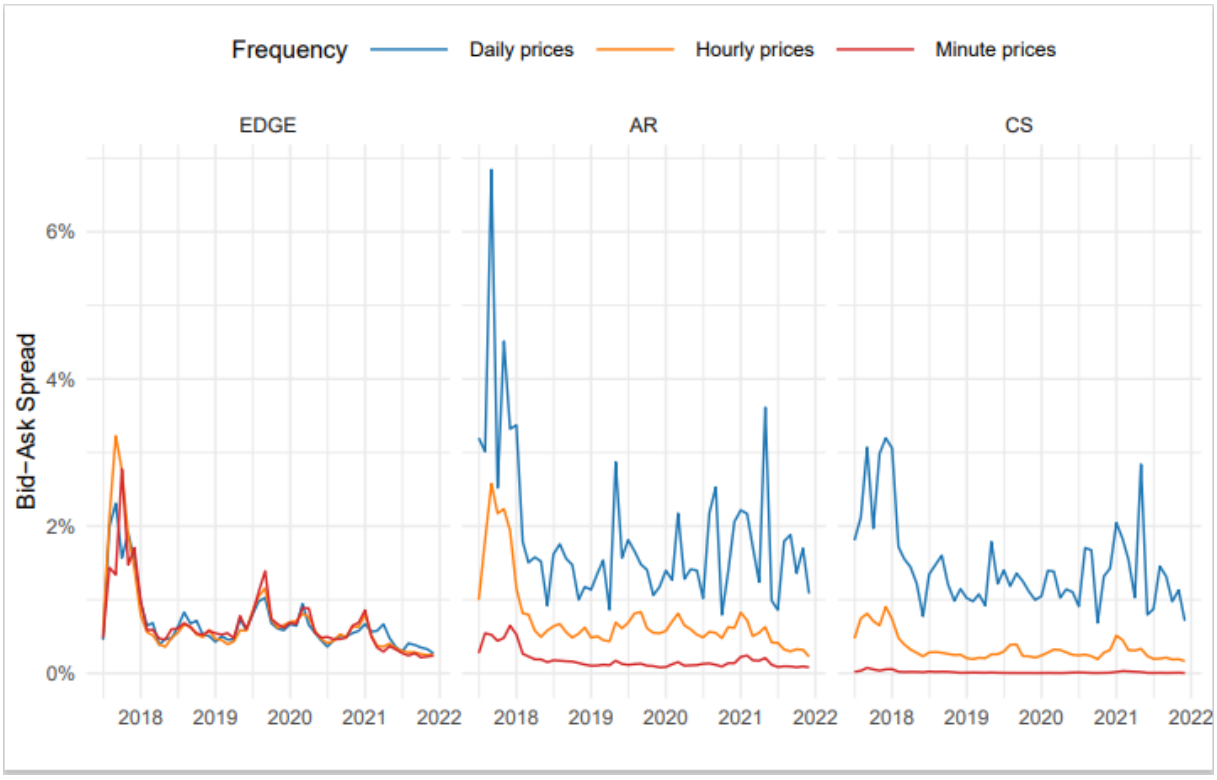
4.9. FIGURE 6: LOW-FREQUENCY ESTIMATES FOR U.S. STOCKS



4.10. FIGURE 7: HIGH-FREQUENCY ESTIMATES FOR U.S. STOCKS



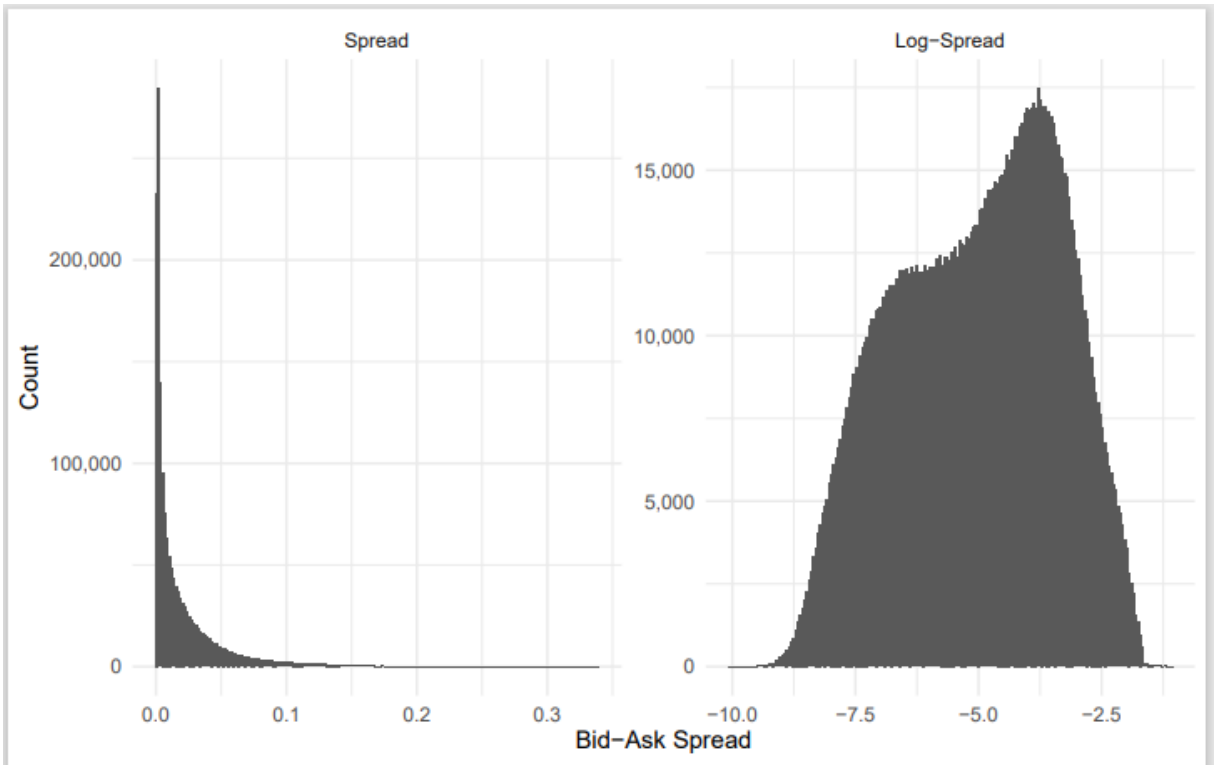
4.11. FIGURE 8: LOW- AND HIGH-FREQUENCY ESTIMATES FOR CRYPTOCURRENCIES



4.12. TABLE I.2: SUMMARY STATISTICS OF NEGATIVE ESTIMATES

VALUE	EDGE	OHLC	CHLO	OHL	CHL	AR	CS	ROLL
N	419617.00	486690.00	507074.00	490702.00	512542.00	521928.00	465952.00	533543.00
COR1	54.23	57.43	59.41	53.84	55.56	36.01	21.47	38.57
COR2	45.95	48.29	49.73	49.24	50.61	41.02	21.78	40.41

4.13. FIGURE I.2: DAILY OPEN, HIGH, LOW, AND CLOSE PRICES FOR INDIVIDUAL STOCKS



4.14. TABLE I.4: SPEARMAN'S CORRELATION WITH THE HJ BENCHMARK

Panel A

EXCHCD	EDGE	OHLC	CHLO	OHL	CHL	AR	CS	ROLL
1	**22.98**	17.85	21.99	17.47	19.20	17.37	2.69	10.62
2	**49.52**	37.02	47.01	38.11	46.21	43.39	17.72	37.99
3	**72.29**	60.68	64.21	58.34	60.89	57.64	30.80	45.92

Panel B

PERIOD	EDGE	OHLC	CHLO	OHL	CHL	AR	CS	ROLL
1	**83.91**	74.62	75.72	75.67	76.90	74.39	53.19	66.76
2	**72.18**	59.47	64.86	57.64	61.96	58.87	40.30	48.53
3	**63.53**	47.01	60.06	45.36	55.81	53.32	28.03	42.23
4	**56.71**	49.83	42.68	47.34	41.38	41.20	23.52	29.37
5	**58.82**	49.68	43.98	51.79	46.13	47.51	31.53	33.63
6	**54.14**	46.60	40.58	47.87	43.71	44.96	40.68	31.10
7	**49.35**	43.41	35.91	42.95	36.48	37.96	42.80	25.06

Panel C

TCAP5	EDGE	OHLC	CHLO	OHL	CHL	AR	CS	ROLL
1	**71.50**	56.30	65.57	57.39	65.39	60.85	28.17	53.76
2	**64.83**	51.84	57.97	50.52	55.71	50.15	19.71	42.05
3	**60.82**	52.18	52.64	46.92	46.03	42.84	23.87	29.00
4	**43.85**	38.26	38.56	33.48	32.10	30.76	21.68	18.82
5	**26.88**	24.15	23.85	22.18	20.83	20.17	14.53	14.00

Panel D

SPREAD5	EDGE	OHLC	CHLO	OHL	CHL	AR	CS	ROLL
1	**13.68**	11.53	12.37	12.46	12.00	11.40	7.22	8.83
2	**31.60**	27.75	26.98	23.00	20.76	19.56	13.95	10.09
3	**50.83**	43.85	44.23	37.35	36.23	33.68	23.49	19.15
4	**61.52**	49.05	55.05	47.35	52.10	47.51	25.32	35.88
5	**69.49**	53.41	62.53	55.90	64.05	58.29	21.81	56.12

Panel E

NUMTRD5	EDGE	OHLC	CHLO	OHL	CHL	AR	CS	ROLL
1	**72.68**	58.35	64.90	60.83	66.75	64.32	33.88	63.10
2	**72.25**	61.54	63.17	59.19	60.14	59.00	43.17	45.44
3	**61.22**	54.60	51.83	48.60	44.82	44.27	36.75	29.87
4	**45.85**	42.07	37.16	37.95	33.01	32.89	32.74	22.75
5	**27.49**	25.90	22.83	23.64	20.30	19.80	19.78	15.75

4.15. TABLE I.5: MEAN ABSOLUTE PERCENTAGE ERROR WITH THE HJ BENCHMARK

Panel A

EXCHCD	EDGE	OHLC	CHLO	OHL	CHL	AR	CS	ROLL
1	21.12	23.96	22.06	26.77	25.55	25.19	**20.72**	32.92
2	13.93	15.80	**13.64**	16.59	14.37	17.00	50.66	17.56
3	**14.77**	17.41	15.62	18.64	16.98	18.32	39.91	21.94

Panel B

PERIOD	EDGE	OHLC	CHLO	OHL	CHL	AR	CS	ROLL
1	**9.29**	11.14	10.55	11.39	10.71	13.83	58.27	14.15
2	**11.32**	13.76	12.77	14.64	13.77	15.05	48.19	18.24
3	**14.49**	16.99	15.46	18.27	17.05	17.79	43.41	22.29
4	**19.09**	22.13	19.15	24.10	21.50	21.81	25.22	27.15
5	**23.23**	25.93	24.36	28.21	26.90	27.11	28.91	33.10
6	**20.38**	23.35	21.29	25.42	23.40	23.53	22.32	30.04
7	21.65	24.88	22.83	27.31	25.64	25.52	**20.72**	33.26

Panel C

TCAP5	EDGE	OHLC	CHLO	OHL	CHL	AR	CS	ROLL
1	**13.37**	15.82	14.38	16.42	14.92	16.96	61.84	18.54
2	**12.93**	15.31	13.65	16.09	14.44	16.88	43.95	18.27
3	**14.10**	16.63	14.74	18.44	16.83	17.48	28.17	22.26
4	**18.76**	21.63	19.51	24.39	22.77	22.60	21.19	30.01
5	24.43	27.35	25.41	29.84	28.48	28.12	**20.21**	36.14

Panel D

SPREAD5	EDGE	OHLC	CHLO	OHL	CHL	AR	CS	ROLL
1	26.09	29.24	27.09	31.93	30.47	30.13	**19.15**	38.17
2	19.56	22.42	20.23	25.44	23.84	23.44	**18.79**	31.33
3	**15.09**	17.86	15.38	19.93	17.81	17.86	21.93	24.05
4	**11.96**	14.45	12.54	15.16	13.23	14.54	34.55	17.20
5	**12.28**	14.26	13.65	14.33	13.58	17.24	78.46	16.06

Panel E

NUMTRD5	EDGE	OHLC	CHLO	OHL	CHL	AR	CS	ROLL
1	**11.48**	12.88	12.66	12.78	12.46	16.98	82.35	14.37
2	**11.25**	13.72	12.10	14.63	12.98	13.43	34.14	17.13
3	**15.21**	18.13	15.59	20.48	18.34	18.30	22.29	24.70
4	20.50	23.66	21.17	26.53	24.61	24.31	**19.45**	32.25
5	26.51	29.65	27.63	32.17	30.73	30.38	**20.57**	38.57

4.16. TABLE I.6: ROOT MEAN SQUARED ERROR WITH THE HJ BENCHMARK

Panel A

EXCHCD	EDGE	OHLC	CHLO	OHL	CHL	AR	CS	ROLL
1	1.76	1.95	1.82	2.11	2.02	2.00	**1.60**	2.52
2	0.79	0.88	**0.75**	0.93	0.79	0.88	3.17	0.98
3	**1.03**	1.16	1.05	1.26	1.17	1.18	2.83	1.49

Panel B

PERIOD	EDGE	OHLC	CHLO	OHL	CHL	AR	CS	ROLL
1	**0.52**	0.55	**0.52**	0.56	0.53	0.64	3.91	0.70
2	**0.63**	0.73	0.68	0.79	0.75	0.79	3.19	1.01
3	**0.87**	1.00	0.91	1.10	1.02	1.04	3.04	1.35
4	**1.39**	1.57	1.43	1.70	1.59	1.58	1.74	1.99
5	**1.69**	1.85	1.78	1.98	1.94	1.91	1.88	2.37
6	1.61	1.80	1.67	1.92	1.81	1.79	**1.55**	2.28
7	1.70	1.90	1.80	2.05	1.97	1.95	**1.54**	2.48

Panel C

TCAP5	EDGE	OHLC	CHLO	OHL	CHL	AR	CS	ROLL
1	**0.72**	0.81	**0.72**	0.85	0.76	0.82	4.03	0.96
2	**0.78**	0.89	0.80	0.95	0.87	0.93	2.80	1.10
3	**0.98**	1.12	1.01	1.24	1.16	1.16	1.92	1.51
4	**1.45**	1.63	1.49	1.79	1.70	1.68	1.56	2.17
5	2.04	2.23	2.10	2.39	2.30	2.28	**1.64**	2.83

Panel D

SPREAD5	EDGE	OHLC	CHLO	OHL	CHL	AR	CS	ROLL
1	2.11	2.32	2.18	2.48	2.38	2.36	**1.59**	2.91
2	1.51	1.68	1.55	1.85	1.76	1.74	**1.39**	2.23
3	**1.04**	1.19	1.06	1.33	1.23	1.22	1.43	1.60
4	**0.71**	0.82	0.72	0.88	0.78	0.82	2.06	1.01
5	0.58	0.62	0.58	0.62	**0.57**	0.71	4.63	0.68

Panel E

NUMTRD5	EDGE	OHLC	CHLO	OHL	CHL	AR	CS	ROLL
1	0.58	0.58	0.57	0.57	**0.55**	0.73	4.72	0.62
2	**0.62**	0.73	0.65	0.79	0.72	0.73	2.14	0.94
3	**1.01**	1.16	1.02	1.31	1.21	1.20	1.56	1.59
4	1.51	1.69	1.55	1.86	1.77	1.75	**1.42**	2.25
5	2.14	2.34	2.22	2.50	2.41	2.39	**1.66**	2.94

4.17. TABLE I.7: FRACTION OF NON-POSITIVE ESTIMATES

Panel A

EXCHCD	EDGE	OHLC	CHLO	OHL	CHL	AR	CS	ROLL
1	40.90	44.50	42.34	42.75	42.19	44.10	42.01	**40.06**
2	**25.84**	30.89	32.43	30.69	31.83	31.29	40.30	32.75
3	**18.34**	22.58	25.40	23.81	26.06	26.13	21.76	29.04

Panel B

PERIOD	EDGE	OHLC	CHLO	OHL	CHL	AR	CS	ROLL
1	**15.50**	19.02	18.76	21.34	21.99	22.26	26.12	26.31
2	**22.47**	27.31	25.51	29.82	29.51	29.99	34.76	31.85
3	**24.55**	31.40	27.03	32.85	30.49	30.92	35.42	32.26
4	**27.07**	30.58	35.40	29.86	33.47	33.67	28.59	35.13
5	**26.38**	32.84	32.91	30.42	31.30	31.81	26.79	33.10
6	31.47	33.89	39.30	32.89	36.36	37.41	**25.16**	35.89
7	34.70	37.15	40.84	35.54	37.98	39.18	**27.33**	35.02

Panel C

TCAP5	EDGE	OHLC	CHLO	OHL	CHL	AR	CS	ROLL
1	**15.64**	21.09	21.48	22.21	22.74	22.21	24.72	25.95
2	**17.42**	22.34	24.38	23.00	24.72	24.33	25.52	27.61
3	**23.13**	26.99	29.70	27.48	29.97	30.37	26.56	32.96
4	33.18	36.35	37.55	35.94	37.31	38.75	**31.95**	37.07
5	38.77	41.93	41.76	41.23	41.77	43.71	**37.16**	39.42

Panel D

SPREAD5	EDGE	OHLC	CHLO	OHL	CHL	AR	CS	ROLL
1	41.85	44.73	44.18	43.29	43.50	45.65	**38.06**	40.27
2	34.63	37.99	39.02	37.57	38.92	40.46	**33.63**	38.69
3	**24.94**	28.44	31.89	29.56	32.62	33.24	27.54	35.55
4	**15.97**	20.17	23.32	21.88	24.74	24.29	23.92	29.14
5	**10.75**	17.33	16.44	17.54	16.72	15.70	22.74	19.34

Panel E

NUMTRD5	EDGE	OHLC	CHLO	OHL	CHL	AR	CS	ROLL
1	**13.74**	21.14	17.64	20.67	17.98	17.42	29.40	19.92
2	**16.24**	20.48	22.94	22.51	25.13	24.82	25.12	30.33
3	**24.40**	28.08	32.00	28.29	31.76	32.07	25.37	34.58
4	33.61	36.45	39.20	36.08	38.36	39.64	**29.58**	37.96
5	40.15	42.55	43.10	42.30	43.28	45.42	**36.43**	40.23

4.18. TABLE I.8: PEARSON'S CORRELATION OF YEARLY ESTIMATES WITH THE HJ BENCHMARK

Panel A

EXCHCD	EDGE	OHLC	CHLO	OHL	CHL	AR	CS	ROLL
1	**15.44**	11.68	13.67	11.40	12.48	11.74	13.10	7.78
2	**21.99**	16.33	19.13	17.75	20.05	20.41	19.40	9.49
3	**30.82**	23.73	25.19	24.43	25.81	25.04	18.75	16.39

Panel B

PERIOD	EDGE	OHLC	CHLO	OHL	CHL	AR	CS	ROLL
1	**32.83**	25.15	25.94	26.68	27.59	27.78	19.49	22.22
2	**32.29**	24.63	26.64	25.05	27.06	27.28	21.16	20.41
3	**31.51**	23.49	28.62	23.98	27.88	30.43	24.34	22.16
4	**23.70**	18.42	18.38	18.77	18.65	17.04	13.26	2.99
5	**25.30**	21.08	19.11	21.49	19.24	19.80	13.12	11.77
6	**13.48**	11.73	9.31	12.61	10.35	10.43	10.54	2.04
7	**13.79**	11.85	8.95	13.08	10.16	9.38	11.51	2.95

Panel C

TCAP5	EDGE	OHLC	CHLO	OHL	CHL	AR	CS	ROLL
1	**31.34**	23.96	26.04	24.86	26.72	27.54	21.17	18.77
2	**27.51**	21.34	22.01	22.18	22.80	21.10	16.19	13.33
3	**27.16**	20.97	21.99	21.28	21.84	19.53	15.35	11.20
4	**22.96**	17.77	19.76	17.15	18.99	16.24	14.30	7.98
5	**16.42**	13.44	13.86	12.76	13.05	11.04	9.64	8.39

Panel D

SPREAD5	EDGE	OHLC	CHLO	OHL	CHL	AR	CS	ROLL
1	4.22	**4.87**	3.47	4.77	3.55	4.24	3.67	3.94
2	**12.58**	10.76	10.96	10.36	10.01	10.11	9.76	6.32
3	**21.42**	17.00	17.80	16.71	17.32	15.88	16.18	7.65
4	**28.97**	22.01	24.09	22.33	23.97	22.98	19.40	12.13
5	**31.43**	24.24	25.58	25.43	26.60	27.77	20.20	19.39

Panel E

NUMTRD5	EDGE	OHLC	CHLO	OHL	CHL	AR	CS	ROLL
1	**29.94**	23.17	24.67	24.33	25.64	27.07	16.56	22.59
2	**34.18**	25.77	27.45	26.66	28.09	28.09	24.89	14.46
3	**27.56**	21.46	22.43	21.30	21.76	20.36	20.74	8.91
4	**20.15**	15.97	16.65	15.79	16.29	14.59	15.93	6.74
5	**12.39**	10.96	10.77	10.22	10.07	8.93	9.93	4.83

4.19. TABLE I.9: PEARSON'S CORRELATION OF YEARLY ESTIMATES WITH THE HJ BENCHMARK

Panel A

EXCHCD	EDGE	OHLC	CHLO	OHL	CHL	AR	CS	ROLL
1	**74.17**	66.98	70.93	66.76	69.06	56.35	58.89	35.72
2	**76.85**	67.56	75.57	69.50	76.40	64.59	45.33	42.23
3	**86.54**	79.71	83.60	80.20	83.09	78.43	49.89	62.94

Panel B

PERIOD	EDGE	OHLC	CHLO	OHL	CHL	AR	CS	ROLL
1	**88.27**	83.89	85.02	85.30	86.09	83.02	52.46	80.14
2	**87.52**	79.94	84.25	81.09	84.06	81.77	54.39	74.52
3	**85.73**	73.21	84.72	75.27	84.14	82.02	52.91	74.98
4	**76.21**	67.34	71.30	68.64	70.32	64.25	47.23	34.06
5	**80.29**	76.57	74.68	76.05	73.03	68.32	48.62	43.58
6	**70.78**	63.56	63.91	64.94	64.32	63.62	51.92	32.02
7	**63.73**	58.34	54.63	58.54	53.62	50.81	52.09	27.82

Panel C

TCAP5	EDGE	OHLC	CHLO	OHL	CHL	AR	CS	ROLL
1	**82.80**	73.76	79.97	75.38	80.19	74.87	42.42	62.40
2	**80.64**	72.48	77.33	73.38	77.50	64.95	36.99	49.91
3	**82.49**	76.15	79.01	74.79	76.45	64.40	46.87	43.24
4	**82.55**	75.85	81.54	72.88	76.99	65.84	54.12	31.89
5	**78.31**	71.00	76.70	68.34	71.59	61.95	58.96	39.53

Panel D

SPREAD5	EDGE	OHLC	CHLO	OHL	CHL	AR	CS	ROLL
1	**23.91**	22.14	21.58	19.70	17.65	16.01	17.99	6.95
2	**52.04**	50.50	46.69	43.11	37.40	32.46	39.33	13.30
3	**67.97**	62.29	62.80	58.62	57.75	46.96	49.02	21.11
4	**77.37**	66.28	76.75	66.68	76.04	66.42	45.87	42.26
5	**80.43**	71.18	76.82	73.31	77.50	71.45	36.99	62.02

Panel E

NUMTRD5	EDGE	OHLC	CHLO	OHL	CHL	AR	CS	ROLL
1	**83.59**	76.27	79.77	78.11	80.38	78.24	47.76	77.30
2	**88.24**	81.52	85.93	82.04	85.95	81.45	63.30	55.62
3	**83.86**	77.56	81.10	75.93	78.43	69.37	61.20	40.14
4	**74.16**	70.80	67.81	68.32	64.25	57.04	62.84	33.50
5	**68.26**	62.99	62.02	60.06	56.85	48.64	55.44	26.63