Effectiveness of domain stabilization: Evidence from the KOSPI 200 options market

Geul Lee

Department of Economics
Sungkyunkwan University

KAFE Fall Conference
November 29, 2024

Background

Bakshi, Kapadia, and Madan (BKM; 2003)

The volatility, skewness, and kurtosis of the implied risk-neutral log-return density can be derived from out-of-the-money option prices without relying on any model

- The implied moments contain information about the market participants' expectations of the underlying asset price dynamics
- A popular estimation method:
  (1) The moments are single figures, ready-made for empirical studies
  (2) No worries about assumptions

The BKM estimators

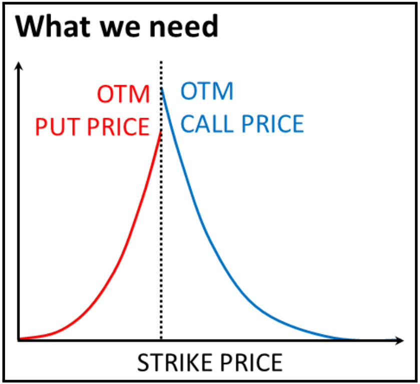
We only need to integrate out-of-the-money (OTM) option prices

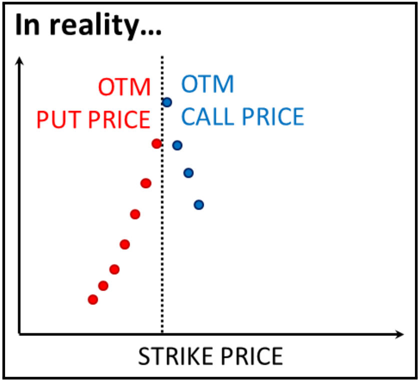
We can calculate V, W, X by integrating weighted OTM option prices with respect to strike price

$$V(t,\tau) = \int_{S(t)}^{\infty} \frac{2\left(1 - \ln\left[\frac{K}{S(t)}\right]\right)}{K^2} C(t,\tau;K)dK + \int_{0}^{S(t)} \frac{2\left(1 + \ln\left[\frac{S(t)}{K}\right]\right)}{K^2} P(t,\tau;K)dK,$$

Limited OTM option price availability

Requirement: OTM option prices for the strike prices $\{K : 0 \leq K < \infty\}$
Available: OTM option prices only for a limited set of strike prices

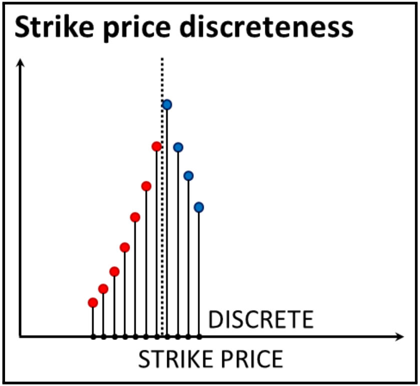


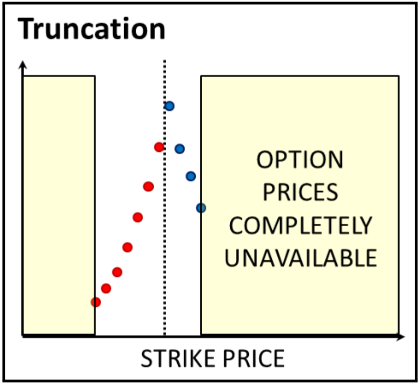


Motivation

We can characterize the limitation as discreteness and truncation

Discreteness: option prices available only for a discrete set of strike prices
Truncation : DOTM option prices completely unavailable





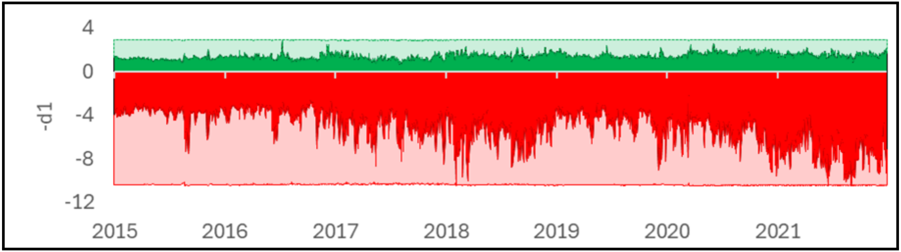
Which one is harder to deal with?

- Discreteness: Numerical methods for interpolation are available, and interpolation is more reliable than extrapolation
- Truncation: Information is more limited for the strike price domain beyond the minimum and maximum strike prices and, therefore, a stronger assumption is required for approximation

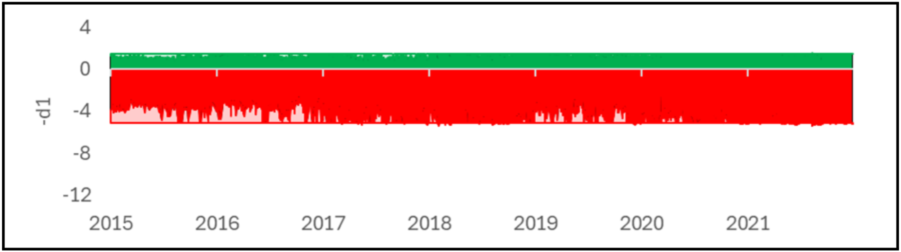
Domain stabilization

- Lee, Ryu, and Yang (2024) propose a new remedy for truncation error, called domain stabilization (DStab)
- DStab stabilizes the Black-Scholes d_1 of integration domain endpoints either by linear extrapolation or further discarding observations
- As the DStab intensity level increases, DStab relies more heavily on discarding observations

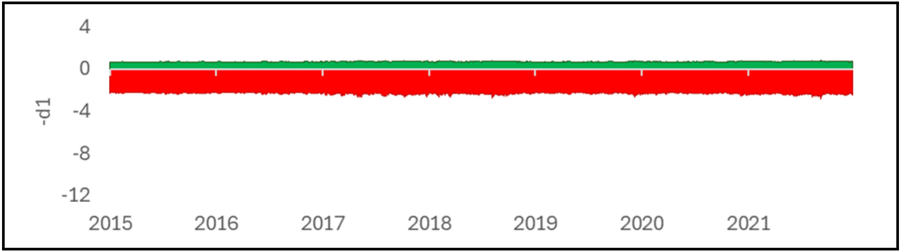
0% DStab



50% DStab



100% DStab



Research objective

- Lee, Ryu, and Yang (2024) demonstrate that DStab improves both in-sample return predictability and out-of-sample forecasting accuracy in the S&P 500 index options market
- In this study, we investigate whether similar results can be achieved in the KOSPI 200 index options market

Data

- KOSPI 200 index options, daily data, spanning from January 2015 to December 2023
- We remove options that are not OTM, have transaction price below 0.03, have incomplete data entries, or violate the no-arbitrage condition
- We extract daily implied volatility curves for a one-month maturity from daily implied volatility surfaces constructed using observations from the final dataset

Models

- Explanatory power of implied moments: Levels

$$\ln\left[S(t)\right] = \alpha + \beta_0 \cdot VOL(t) + \beta_1 \cdot SKEW(t) + \beta_2 \cdot KURT(t) + \varepsilon(t)$$

- Explanatory power of implied moments: First-order differences

$$\Delta \ln\left[S(t)\right] = \alpha + \beta_0 \cdot \Delta VOL(t) + \beta_1 \cdot \Delta SKEW(t) + \beta_2 \cdot \Delta KURT(t) + \varepsilon(t)$$

- In-sample return predictive and out-of-sample return forecasting ability

$$\Delta \ln\left[S(t)\right] = \alpha + \beta \cdot \Delta \ln\left[S(t-1)\right] + \gamma_0 \cdot \Delta VOL(t-1) + \gamma_1 \cdot \Delta SKEW(t-1) + \gamma_2 \cdot \Delta KURT(t-1) + \varepsilon(t)$$

Explanatory power of implied moments

		No stabilization	0 percent stabilization	25 percent stabilization	50 percent stabilization	75 percent stabilization	100 percent stabilization
VOL(*t*)		0.294	0.324	0.360	0.361	0.360	-0.042
		(0.91)	(1.03)	(1.17)	(1.17)	(1.16)	(-0.55)
SKEW(*t*)		0.134***	0.151***	0.229***	0.255***	0.287***	0.869***
		(2.63)	(2.80)	(3.33)	(3.40)	(3.49)	(13.71)
KURT(*t*)		0.027***	0.025***	0.054***	0.068***	0.085***	0.422***
		(2.87)	(2.61)	(2.98)	(2.89)	(2.76)	(6.56)
Intercept		5.641***	5.650***	5.583***	5.559***	5.542***	5.505***
		(125.27)	(122.01)	(94.09)	(80.61)	(68.92)	(90.89)
# of obs.		1,703	1,703	1,703	1,703	1,703	1,703
Unadjusted R^2		0.031	0.033	0.044	0.045	0.047	0.104
AIC	Value	-1470.25	-1474.30	-1494.15	-1495.99	-1499.02	-1604.64
	Diff.	0.00	-4.05	-23.90	-25.74	-28.77	-134.39
BG		1671.1***	1678.6***	1674.1***	1674.6***	1674.6***	1636.9***
BP		25.3***	9.9***	8.9***	7.3***	5.5**	43.5***

Explanatory power of implied moments

		No stabilization	0 percent stabilization	25 percent stabilization	50 percent stabilization	75 percent stabilization	100 percent stabilization
ΔVOL(t)		-47.23***	-40.84***	-40.99***	-41.47***	-42.34***	-59.99***
		(-19.20)	(-16.88)	(-16.39)	(-16.35)	(-16.34)	(-19.06)
ΔSKEW(t)		0.271	1.452***	1.828***	1.838***	1.761***	0.856
		(0.90)	(3.96)	(3.52)	(3.13)	(2.65)	(0.70)
ΔKURT(t)		0.124**	0.247***	0.370***	0.368**	0.288	-1.621**
		(2.54)	(4.31)	(3.28)	(2.37)	(1.31)	(-2.11)
Intercept		0.024	0.024	0.024	0.024	0.023	0.024
		(0.99)	(0.99)	(0.99)	(0.99)	(1.00)	(1.00)
# of obs.		1,702	1,702	1,702	1,702	1,702	1,702
Unadjusted R^2		0.410	0.421	0.423	0.423	0.423	0.423
AIC	Value	4585.56	4549.60	4546.98	4547.30	4547.05	4548.17
	Diff.	0.00	-35.96	-38.58	-38.26	-38.51	-37.39
BG		6.4**	6.7***	6.1**	6.2**	6.4**	6.5**
BP		1.1	75.3***	70.1***	70.9***	71.6***	91.7***

In-sample return predictive ability

	No stabilization	0 percent stabilization	25 percent stabilization	50 percent stabilization	75 percent stabilization	100 percent stabilization
ΔlnS(t-1)	0.021	0.007	0.003	0.003	0.003	-0.002
	(0.61)	(0.23)	(0.10)	(0.11)	(0.10)	(-0.05)
ΔVOL(t-1)	-1.411	-3.341	-2.961	-2.904	-2.927	-3.763
	(-0.36)	(-0.76)	(-0.65)	(-0.64)	(-0.65)	(-0.68)
ΔSKEW(t-1)	-0.738*	-0.612	-0.153	0.037	0.163	-0.716
	(-1.76)	(-1.51)	(-0.33)	(0.08)	(0.33)	(-0.89)
ΔKURT(t-1)	-0.092	-0.067	0.103	0.239*	0.395*	0.957
	(-1.49)	(-1.18)	(1.12)	(1.84)	(1.86)	(0.95)
Intercept	0.022	0.022	0.022	0.022	0.022	0.023
	(0.74)	(0.76)	(0.76)	(0.76)	(0.76)	(0.76)
# of obs.	1,701	1,701	1,701	1,701	1,701	1,701
Unadjusted R^2	0.004	0.002	0.004	0.005	0.005	0.002
AIC Value	5472.94	5476.94	5473.43	5471.21	5471.39	5476.32
AIC Diff.	0.00	4.00	0.49	-1.73	-1.55	3.38
BG	0.7	7.7***	3.8*	3.5*	3.3*	13.1***
BP	37.5***	60.0***	52.3***	61.0***	75.8***	70.8***

Out-of-sample return forecasting ability

Rolling window length	R^2_{OS}					
	No stabilization	0 percent stabilization	25 percent stabilization	50 percent stabilization	75 percent stabilization	100 percent stabilization
5 months	-9.79	-13.96	-13.40	-13.12	-13.51	-13.06
10 months	-4.77	-7.66	-7.86	-7.76	-7.96	-6.58
15 months	-3.97	-6.07	-5.94	-5.75	-5.87	-4.69
20 months	-2.36	-4.21	-4.12	-4.01	-4.11	-3.17
25 months	-1.93	-3.40	-3.09	-2.98	-3.08	-2.65
30 months	-1.98	-2.80	-2.37	-2.23	-2.33	-1.95
35 months	-1.64	-2.12	-1.74	-1.61	-1.74	-1.62
40 months	-1.53	-1.91	-1.62	-1.52	-1.66	-1.51
45 months	-1.27	-1.59	-1.33	-1.20	-1.26	-1.27
50 months	-0.93	-1.29	-1.05	-0.88	-0.91	-1.05
55 months	-1.01	-1.35	-1.10	-0.87	-0.86	-1.03
60 months	-0.86	-1.00	-0.53	-0.36	-0.40	-0.71
65 months	-1.33	-1.16	-0.45	-0.25	-0.31	-0.57
70 months	-1.00	-0.66	-0.28	-0.21	-0.25	-0.38
75 months	-1.15	-0.56	-0.21	0.11	0.05	-0.53
80 months	-2.29	-0.84	0.07	0.45	0.59	-0.14

Conclusions

- DStab is effective for the KOSPI200 index options market, as in the S&P 500 index options market
- We apply a minimum option price threshold of 0.03, following the previous studies examining the KOSPI 200 index options market

Thank you for your attention!