

Appendix A. Algorithm details

Algorithm 1 Functional CORN-K: Expert Procedure ($\epsilon(w, \rho, \lambda)$).

Input:

$\mathbf{X}_1^{t-1} = (\mathbf{x}_1, \dots, \mathbf{x}_{t-1})$: historical market relative price sequence;
 w : value of window size;
 ρ : value of threshold
 λ : value of scale factor.

Output:

$\mathbf{b}_t^*(w, \rho, \lambda)$: Expert's optimal portfolio

- 1: Initialize the weight vector: $v_1 = 0, \dots, v_{t-w-1} = 0$
- 2: **if** $t \leq w + 1$ **then**
- 3: **return** $\mathbf{b}_t = \{\frac{1}{m}, \dots, \frac{1}{m}\}$;
- 4: **end if**
- 5: **for** $i = w + 1$ to $t - 1$ **do**
- 6: $c = \mathcal{R}(\mathbf{X}_{i-w}^{i-1}, \mathbf{X}_{t-w}^{t-1})$;
- 7:
$$v_i = \begin{cases} \frac{1}{1+\exp(-\lambda(c-\rho))} & c \geq 0, \\ \frac{1}{1+\exp(-\lambda(c+\rho))} - 1 & c < 0 \end{cases}$$
- 8: **end for**
- 9: Optimize the portfolio:
- 10: $\mathbf{b}_t^*(w, \rho, \lambda) = \operatorname{argmax}_{\mathbf{b}_t \in \Delta_m} \sum_{i \in \{w+1, \dots, t-1\}} v_i \log(\mathbf{b}_t^T \mathbf{x}_i)$
- 11: **return** \mathbf{b}_t

Algorithm 2 Functional CORN-K: Ensemble algorithm.

Input:

$\mathbf{X}_1^{t-1} = (\mathbf{x}_1, \dots, \mathbf{x}_{t-1})$: historical market relative price sequence;
 W : maximum window size for experts;
 $\varrho = (\rho_1, \dots, \rho_P)$: set of threshold values;
 $\Lambda = (\lambda_1, \dots, \lambda_L)$: set of scale factor.

Output:

\mathbf{b}_t^* : Ensemble portfolio

- 1: Initialize $S_0 = 1$;
- 2: **for** $w = 1$ to W **do**
- 3: **for** each $\rho \in \varrho$ **do**
- 4: **for** each $\lambda \in \Lambda$ **do**
- 5: Expert procedure:
- 6: $b_t^*(w, \rho, \lambda) = \epsilon(w, \rho, \lambda)$
- 7: **end for**
- 8: **end for**
- 9: **end for**
- 10: Ensemble experts:

$$\mathbf{b}_t^* = \frac{\sum_{\epsilon(w, \rho, \lambda) \in E_t} S_{t-1}(w, \rho, \lambda) \mathbf{b}_t^*(w, \rho, \lambda)}{\sum_{\epsilon(w, \rho, \lambda) \in E_t} S_{t-1}(w, \rho, \lambda)}$$

Appendix B. Performance

Exhibit B.1 gives a more visualized comparison for SCORN-K and CORN-K, where different configurations of the algorithms are shown, and the RET improvement is represented by color. It can be seen that the configuration which obtains the best improvement is roughly the same for different markets, demonstrating that the improvement does not rely on market-dependent tuning.

EXHIBIT B.1: Improvements of SCORN-K over CORN-K. The color represents the relative RET improvement.

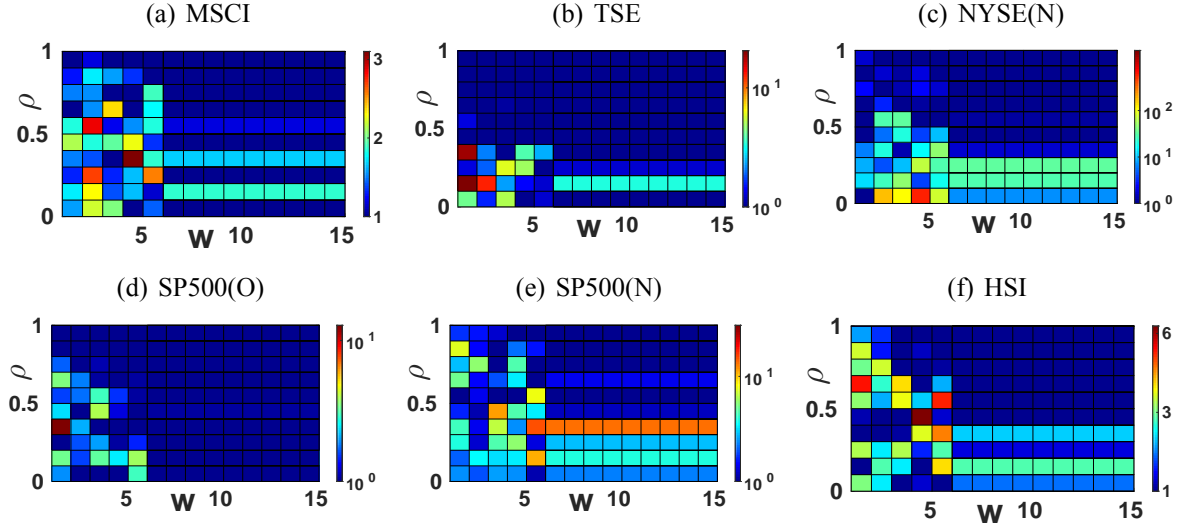


EXHIBIT B.2: Results of the t-test for the RET improvement for FCORN-K and SCORN-K over CORN-K.

(a) FCORN-K vs. CORN-K

Statistics	MSCI	TSE	NYSE(N)	SP500	SP500(N)	HSI
MER(ALGO)	0.0048	0.0025	0.0029	0.0026	0.0012	0.0019
MER(Market)	0.0044	0.0010	0.0023	0.0024	0.0008	0.0016
Winning Ratio	46.79%	52.66%	49.70%	49.53%	50.76%	48.60%
α	0.0006	0.0018	0.0009	0.0009	0.0003	0.0004
β	0.9540	0.6260	0.8897	0.6979	1.0823	0.8844
t-value	2.9288	2.4557	4.5206	1.9485	1.2932	3.4893
p-value	0.0035	0.0142	0.0000	0.0516	0.1960	0.0005

(b) SCORN-K vs. CORN-K

Statistics	MSCI	TSE	NYSE(N)	SP500	SP500(N)	HSI
MER(ALGO)	0.0048	0.0025	0.0027	0.0023	0.0012	0.0018
MER(Market)	0.0044	0.0010	0.0023	0.0024	0.0008	0.0016
Winning Ratio	46.12%	51.07%	48.45%	48.12%	50.57%	48.54%
α	0.0005	0.0018	0.0006	0.0006	0.0003	0.0004
β	0.9526	0.6285	0.8985	0.6677	1.0508	0.8803
t-value	2.6561	2.3757	3.0587	1.4375	1.4222	2.9543
p-value	0.0080	0.0177	0.0022	0.1508	0.1551	0.0032

Appendix C. Parameter sensitivity

EXHIBIT C.1: Parameter sensitivity test: RETs achieved by SCORN-K with different values of window size w and threshold ρ .

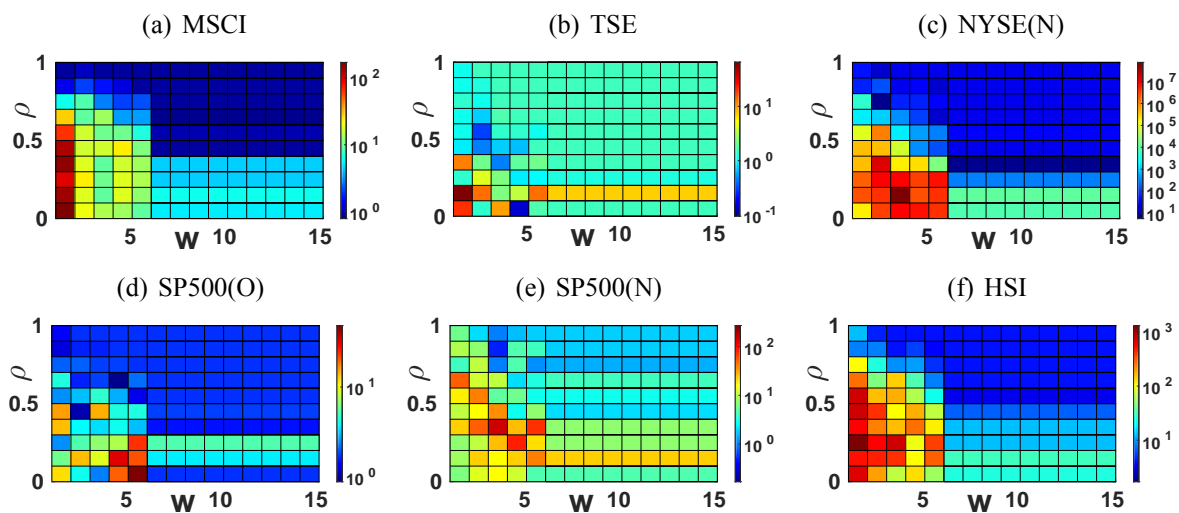


EXHIBIT C.2: Parameter sensitivity test: RETs achieved by FCORN-K with different values of window size w , threshold ρ and scale factor α .

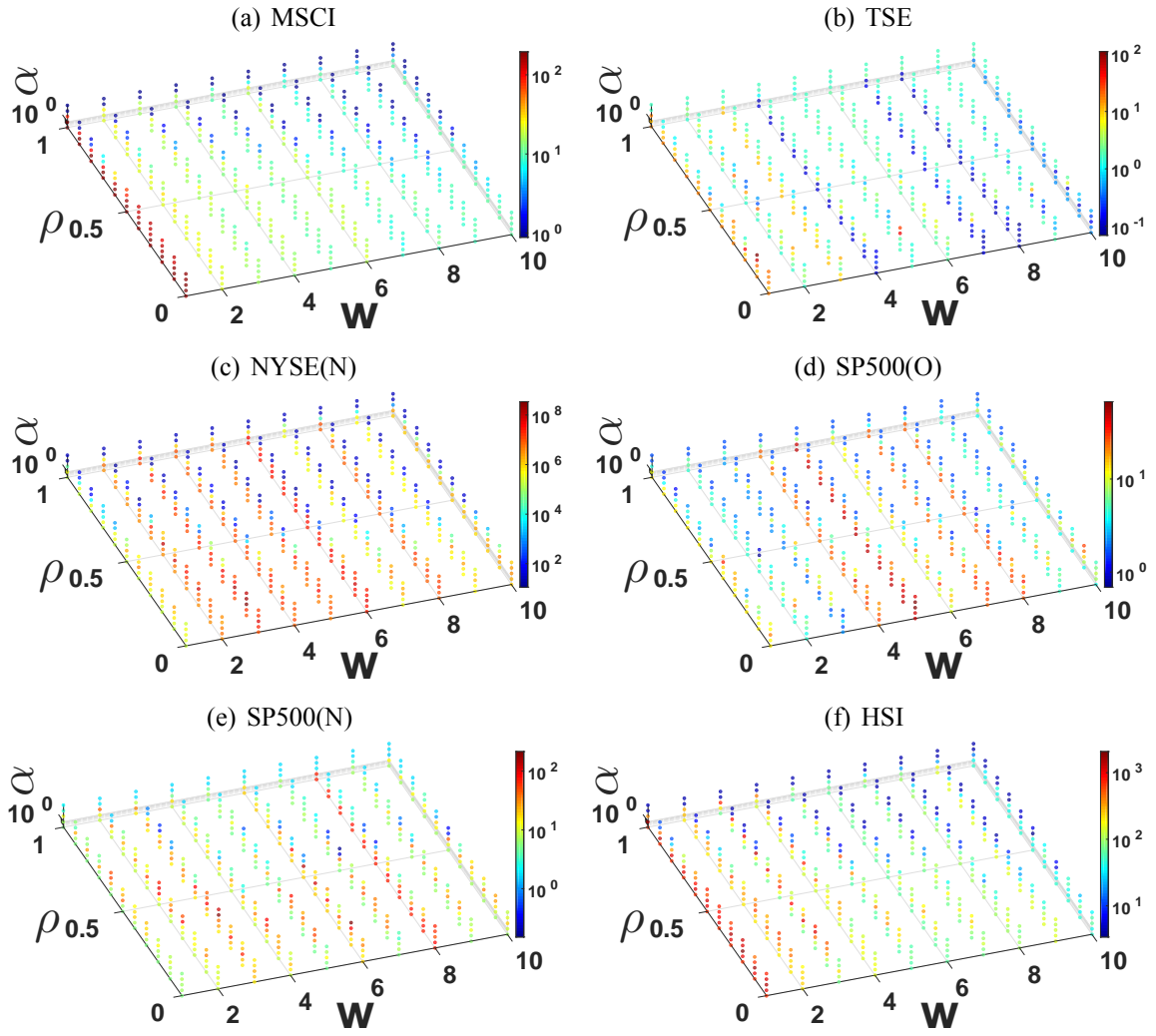
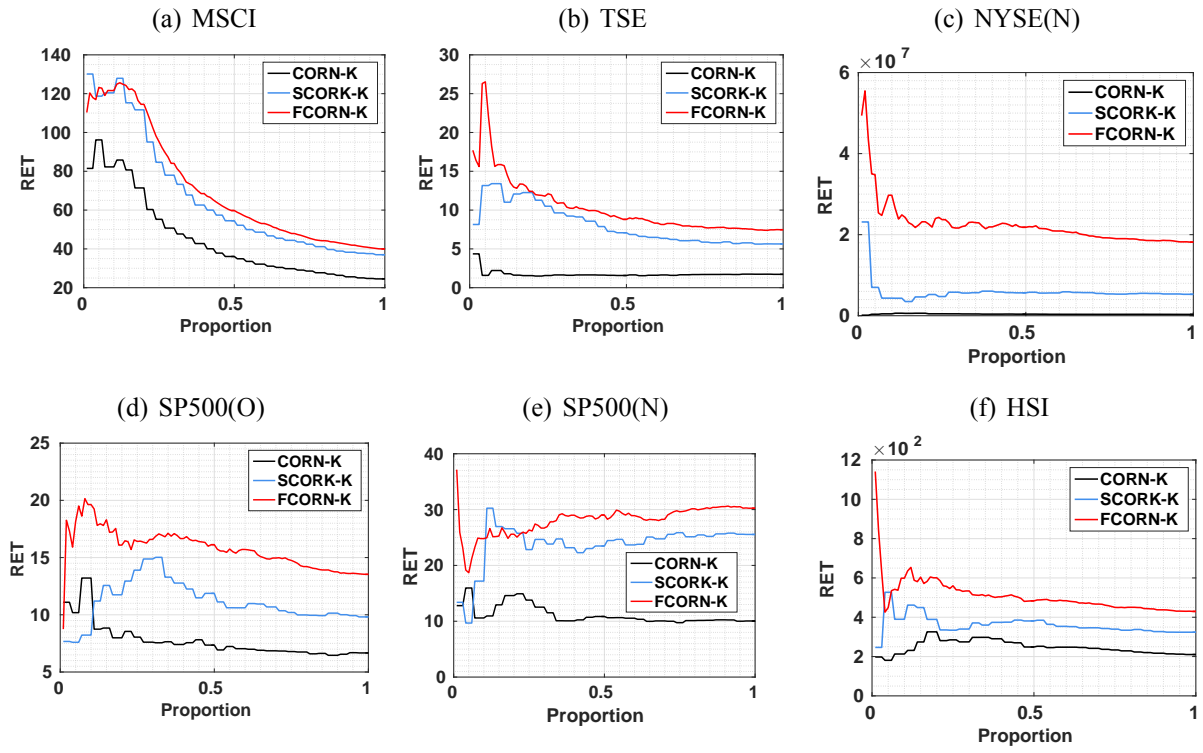
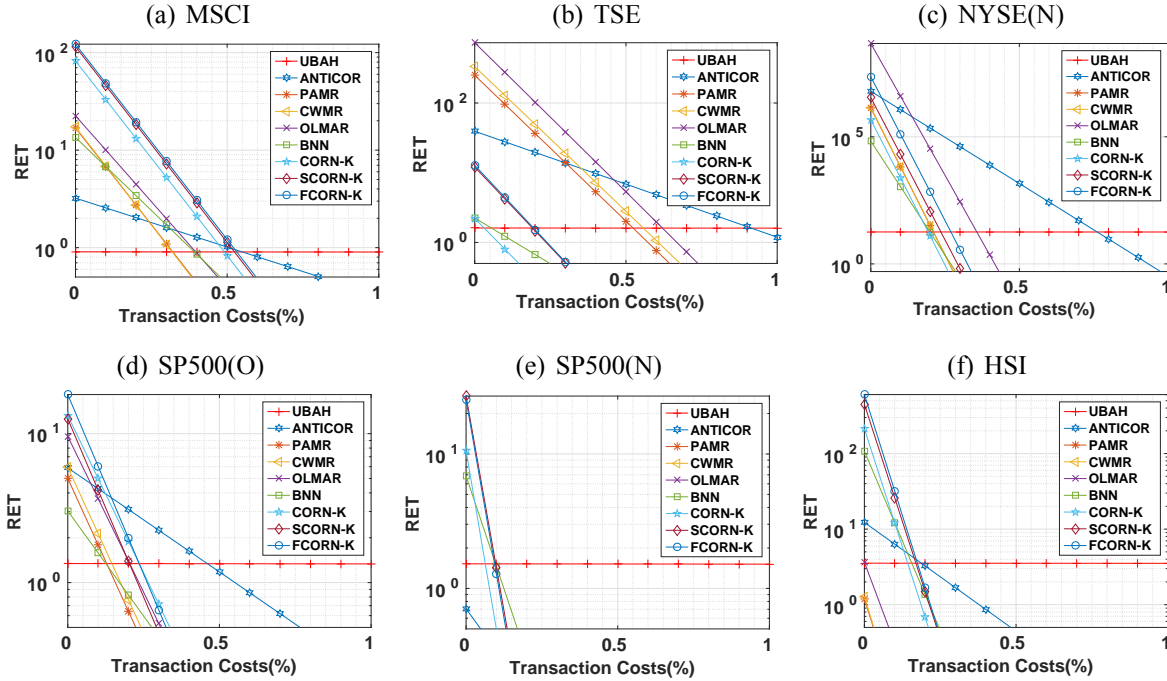


EXHIBIT C.3: RETs with different proportion of experts in the ensemble procedure.



Appendix D. Impact of transaction cost

EXHIBIT D.1: RETs with different transaction cost.



Note that the curves of some strategies can not be seen because the RET values are too small. Besides, it can be seen that the curves of both of SCORN-K and FCORN-K show similar slopes as CORN-K, but these new algorithms possess a higher tolerance on transaction cost than CORN-K in general.