Online appendix to "Commodity momentum and reversal"

Appendix A. Derivations

Derivation of equation (4) in the main text:

$$
\begin{aligned}
R_{s,t\to t+1} &= \frac{S_{t+1}+D_{t\to t+1}^{t+1}}{S_t}-1=\frac{S_{t+1}}{S_t}-1+y_{t\to t+1}\approx\frac{F_{t+1,t+2}e^{y_{t+1\to t+2}-rf_{t+1\to t+2}}}{F_{t,t+2}e^{y_{t\to t+2}-rf_{t\to t+2}}}-1+y_{t\to t+1}\\
&=\frac{F_{t+1,t+2}}{F_{t,t+2}}e^{rf_{t\to t+1}-y_{t\to t+1}}-1+y_{t\to t+1}\approx\ln\left(\frac{F_{t+1,t+2}}{F_{t,t+2}}\right)+rf_{t\to t+1}-y_{t\to t+1}+y_{t\to t+1} \qquad \text{(A.1)}\\
&\approx\frac{F_{t+1,t+2}}{F_{t,t+2}}-1+rf_{t\to t+1}
\end{aligned}
$$

Derivation of equation (5) in the main text:

$$
\begin{aligned}
R_{s,t\to t+1} &= \frac{S_{t+1}+D_{t\to t+1}^{t+1}}{S_t}-1=\frac{S_{t+1}+S_t\left(1+rf_{t\to t+1}\right)-F_{t,t+1}}{S_t}-1\approx\frac{F_{t+1,t+2}}{F_{t,t+2}}-1+rf_{t\to t+1}\\
&=\frac{F_{t+1,t+2}}{F_{t,t+2}}+\frac{F_{t+1,t+2}}{F_{t,t+1}}-\frac{F_{t+1,t+2}}{F_{t,t+1}}-1+rf_{t\to t+1}\approx\frac{F_{t+1,t+2}}{F_{t,t+1}}-\ln\left(\frac{F_{t,t+2}}{F_{t+1,t+2}}\right)-\ln\left(\frac{F_{t+1,t+2}}{F_{t,t+1}}\right)-1+rf_{t\to t+1}\\
&=\frac{F_{t+1,t+2}}{F_{t,t+1}}-\ln\left(\frac{F_{t,t+2}}{F_{t,t+1}}\right)+rf_{t\to t+1}-1\approx\frac{F_{t+1,t+2}}{F_{t,t+1}}-\frac{F_{t,t+2}}{F_{t,t+1}}+\left(1+rf_{t\to t+1}\right)-1 \qquad \text{(A.2)}\\
&=\frac{F_{t+1,t+2}+F_{t,t+1}\left(1+rf_{t\to t+1}\right)-F_{t,t+2}}{F_{t,t+1}}-1
\end{aligned}
$$

Appendix B. Tables

Table B.1
The detailed information about the 23 commodities in the dataset.

			Delivery Month		
Commodities	RS	Exchange	Available	Used	Initial Date
Soybean oil	ZL	CBOT	1 3 5 7 8 9 10 12	1 3 5 7 9 12	1960 09
Soybean meal	ZM	CBOT	1 3 5 7 8 9 10 12	1 3 5 7 9 12	1960 09
Soybean	ZS	CBOT	1 3 5 7 8 9 11	1 3 5 7 9 11	1960 09
Copper	HG	COMEX	1 3 5 7 9 12	1 3 5 7 9 12	1960 09
Cocoa	CC	ICEUS	3 5 7 9 12	3 5 7 9 12	1960 09
Cotton	CT	ICEUS	3 5 7 10 12	3 5 7 10 12	1960 09
Oats	ZO	CBOT	3 5 7 9 12	3 5 7 9 12	1960 09
Corn	ZC	CBOT	3 5 7 9 12	3 5 7 9 12	1960 09
Wheat	ZW	CBOT	3 5 7 9 12	3 5 7 9 12	1960 09
Live cattle	LE	CME	2 4 6 8 10 12	2 4 6 8 10 12	1965 01
Orange juice	OJ	ICEUS	1 3 5 7 9 11	1 3 5 7 9 11	1967 09
Silver	SI	COMEX	3 5 7 9 12	3 5 7 9 12	1967 07
Lean hogs	HE	CME	2 4 5 6 7 8 10 12	2 4 6 8 10 12	1968 11
Lumber	LS	CME	1 3 5 7 9 11	1 3 5 7 9 11	1970 01
Coffee	KC	ICEUS	3 5 7 9 12	3 5 7 9 12	1972 11
Gold	GC	COMEX	2 4 6 8 10 12	2 4 6 8 10 12	1975 01
Feeder cattle	GF	CME	1 3 4 5 8 9 10 11	1 3 5 8 9 11	1977 01
Heating oil	HO	NYMEX	ALL	1 3 5 7 9 11	1979 01
Crude oil	CL	NYMEX	ALL	1 3 5 7 9 11	1983 05
Gasoline	RB	NYMEX	ALL	1 3 5 7 9 11	1985 01
Gas oil	LF	ICE	ALL	1 3 5 7 9 11	1986 07
Rough rice	ZR	CBOT	1 3 5 7 9 11	1 3 5 7 9 11	1989 05
Natural gas	NG	NYMEX	ALL	1 3 5 7 9 11	1990 05

Note: This table describes the detailed information about the 23 commodities, including the name, root symbol (RS), the exchange on which they are traded, the available delivery month, the used delivery month to construct the price data, and the initial date of the price series. NYMEX is the New York Mercantile Exchange. COMEX is the Commodity Exchange. CBOT is the Chicago Board of Trade. ICE is the Intercontinental Exchange. ICEUS is the ICE Futures U.S. CME is the Chicago Mercantile Exchange.

Table B.2

Annualized returns and percentage yields for winners, losers and winners-losers portfolios with spot returns.

	K=1	K=6	K=12	K=18	K=24	K=30	K=1	K=6	K=12	K=18	K=24	K=30
Panel A: Winners portfolio												
	Annualized average returns (%)						*Annualized Standard deviation for returns (%)*					
J=6	14.39	9.87	8.20	8.60	8.74	8.90	8.30	7.83	7.24	6.99	6.80	6.66
J=12	9.33	7.84	7.15	8.19	8.46	8.94	8.24	7.97	7.59	7.39	7.10	6.94
J=18	9.25	8.37	8.21	8.99	9.20	9.62	8.29	8.24	7.85	7.63	7.31	7.21
J=24	10.70	8.81	8.76	9.80	10.30	10.50	9.29	8.33	8.08	7.85	7.71	7.66
J=30	9.67	9.13	9.62	10.65	10.88	10.82	9.05	8.39	8.22	8.04	7.95	7.90
	Annualized average yields (%)						*Annualized Standard deviation for yields(%)*					
J=6	10.72	8.31	5.66	4.30	3.67	3.29	2.27	2.07	1.83	1.71	1.67	1.61
J=12	10.82	7.44	5.03	3.96	3.49	3.25	2.22	1.97	1.78	1.69	1.63	1.61
J=18	9.83	6.91	4.94	4.13	3.76	3.60	2.25	1.94	1.77	1.69	1.67	1.67
J=24	8.95	6.42	4.73	4.16	3.99	3.88	2.19	1.96	1.73	1.75	1.76	1.77
J=30	8.43	6.35	4.94	4.50	4.29	4.03	2.10	1.90	1.82	1.85	1.86	1.85
Panel B: Losers portfolios												
	Annualized average returns (%)						*Annualized Standard deviation for returns (%)*					
J=6	5.25	7.95	9.00	8.90	8.21	7.74	7.15	6.26	5.97	5.82	5.74	5.81
J=12	7.83	8.42	8.93	8.32	7.55	7.18	6.77	6.23	6.15	6.00	5.94	6.00
J=18	5.92	7.71	7.90	7.16	6.48	6.35	6.78	6.36	6.16	6.13	6.11	6.17
J=24	7.52	7.84	7.45	6.65	6.27	6.32	6.47	6.23	6.20	6.24	6.21	6.27
J=30	6.31	7.26	7.14	6.33	6.21	6.30	6.52	6.60	6.60	6.59	6.59	6.62
	Annualized average yields (%)						*Annualized Standard deviation for yields(%)*					
J=6	-9.19	-6.46	-3.77	-2.39	-1.87	-1.66	2.00	1.77	1.80	1.80	1.74	1.73
J=12	-9.29	-5.85	-3.48	-2.35	-2.01	-1.94	2.02	1.90	1.89	1.84	1.80	1.80
J=18	-7.96	-5.40	-3.39	-2.56	-2.36	-2.24	2.08	1.97	1.92	1.90	1.87	1.85
J=24	-7.06	-4.56	-3.02	-2.42	-2.23	-2.10	2.11	2.01	2.01	2.01	1.97	1.95
J=30	-7.01	-4.90	-3.34	-2.65	-2.36	-2.12	2.02	2.04	2.07	2.07	2.03	1.98
Panel C: Winners-losers portfolios												
	Annualized average returns (%)						*Annualized Standard deviation for returns (%)*					
J=6	9.14	1.93	-0.81	-0.30	0.53	1.16	20.43	16.20	11.94	10.13	8.52	7.75
J=12	1.51	-0.58	-1.78	-0.13	0.91	1.76	19.52	17.21	14.86	12.98	11.36	10.31
J=18	3.33	0.66	0.31	1.84	2.72	3.27	19.29	18.10	16.37	15.10	13.60	12.50
J=24	3.17	0.97	1.31	3.14	4.03	4.18	20.55	18.58	17.51	16.41	15.07	14.27
J=30	3.36	1.87	2.49	4.32	4.67	4.52	18.98	18.06	17.30	16.28	15.63	15.18
	Annualized average yields (%)						*Annualized Standard deviation for yields(%)*					
J=6	19.90	14.77	9.43	6.69	5.54	4.95	6.07	4.55	3.45	2.91	2.53	2.23
J=12	20.11	13.30	8.51	6.31	5.50	5.20	5.58	4.74	4.18	3.60	3.16	2.93
J=18	17.79	12.31	8.34	6.69	6.12	5.84	5.80	4.96	4.37	3.95	3.67	3.37
J=24	16.00	10.98	7.75	6.57	6.22	5.98	5.83	5.07	4.49	4.35	4.09	3.88
J=30	15.44	11.25	8.28	7.15	6.65	6.15	5.76	5.06	4.78	4.58	4.46	4.32

Note: This table reports the annualized returns and percentage yields for winners, losers and winners-losers portfolios. The percentage yield of winners, losers and winners-losers portfolios are constructed in the same way of the construction of portfolios. J is the formation period to rank commodities. K is the holding period for the winners and losers portfolios. One period refers to two months. The sample starts from September 1970 in order to use balanced bimonthly portfolio returns. The sample ends in September 2020.

Table B.3

Risk loadings and pricing errors for spot momentum strategies with one-factor model with yield factor.

	K=1	K=6	K=12	K=18	K=24	K=30	K=1	K=6	K=12	K=18	K=24	K=30
	Spot returns GRS: F=1.47*											
	β_{HML_y}						$t(\beta_{HML_y})$					
J=6	0.40	0.30	0.21	0.19	0.12	0.11	4.25	3.27	3.35	3.63	2.87	3.41
J=12	0.41	0.30	0.26	0.20	0.16	0.15	3.77	3.01	3.36	2.68	2.69	3.59
J=18	0.41	0.33	0.23	0.18	0.15	0.18	4.40	3.30	2.57	2.45	2.58	3.98
J=24	0.41	0.26	0.18	0.16	0.18	0.21	3.13	2.51	2.12	2.12	2.98	4.03
J=30	0.40	0.29	0.21	0.21	0.22	0.21	4.23	4.27	3.35	3.57	3.91	3.91
	α (%)						$t(\alpha)$					
J=6	0.76	-0.25	-0.53	-0.41	-0.15	-0.02	1.48	-0.51	-1.58	-1.68	-0.70	-0.11
J=12	-0.54	-0.66	-0.79	-0.41	-0.14	0.01	-0.99	-1.33	-2.21	-1.37	-0.53	0.04
J=18	-0.22	-0.51	-0.38	-0.04	0.17	0.20	-0.49	-1.08	-0.95	-0.11	0.50	0.67
J=24	-0.26	-0.33	-0.13	0.23	0.33	0.31	-0.46	-0.70	-0.30	0.56	0.89	0.87
J=30	-0.19	-0.23	0.01	0.32	0.37	0.35	-0.45	-0.52	0.02	0.79	0.95	0.95
	R^2 (%)											
J=6	14.83	12.88	11.57	13.06	8.18	8.05						
J=12	17.11	11.47	11.48	9.27	7.08	7.95						
J=18	16.75	12.31	7.34	5.45	4.61	7.78						
J=24	15.36	7.29	4.12	3.48	5.35	7.88						
J=30	16.48	9.47	5.81	6.48	7.26	7.27						

Note: This table reports the risk loadings and pricing errors (α) for spot momentum strategies with constant risk premium. $t(\alpha)$ is corrected with Newey and West (1978) procedure with one lag. The GRS F-statistics are also shown in the table. The null hypothesis of GRS test is that the pricing errors are jointly zero. *, ** and *** denotes 10%, 5% and 1% significance respectively. J is the formation period to rank commodities. K is the holding period for the winners-losers portfolios. One period refers to two months. The sample starts from September 1970 in order to use balanced bimonthly portfolio returns. The sample ends in September 2020.

Table B.4

Pricing errors and GRS tests for spot momentum strategies with constant risk premium.

	K=1	K=6	K=12	K=18	K=24	K=30	K=1	K=6	K=12	K=18	K=24	K=30
	Panel A: CAPM model GRS: F= 1.55*											
	α (%)						$t(\alpha)$					
J=6	1.60	0.40	-0.06	-0.01	0.14	0.24	3.09	0.90	-0.19	-0.05	0.60	1.15
J=12	0.39	0.00	-0.22	0.05	0.22	0.34	0.77	0.00	-0.62	0.15	0.74	1.27
J=18	0.70	0.25	0.18	0.41	0.53	0.59	1.47	0.53	0.44	1.06	1.51	1.86
J=24	0.72	0.31	0.36	0.63	0.75	0.75	1.27	0.64	0.80	1.48	1.90	2.01
J=30	0.73	0.48	0.54	0.80	0.83	0.79	1.48	1.04	1.23	1.93	2.08	2.03
	Panel B: FF3 model GRS: F= 1.48*											
	α (%)						$t(\alpha)$					
J=6	1.46	0.28	-0.18	-0.11	0.04	0.16	2.86	0.62	-0.56	-0.43	0.17	0.79
J=12	0.26	-0.17	-0.37	-0.07	0.12	0.26	0.50	-0.36	-0.97	-0.22	0.41	0.99
J=18	0.58	0.08	0.01	0.27	0.42	0.51	1.23	0.16	0.03	0.70	1.20	1.60
J=24	0.52	0.10	0.19	0.49	0.63	0.65	0.88	0.21	0.42	1.15	1.61	1.76
J=30	0.51	0.31	0.38	0.68	0.75	0.72	1.06	0.68	0.88	1.64	1.86	1.85
	Panel C: FF4 model GRS: F=1.29											
	α (%)						$t(\alpha)$					
J=6	1.00	0.03	-0.33	-0.20	0.00	0.12	1.91	0.06	-0.98	-0.73	0.00	0.55
J=12	-0.04	-0.38	-0.48	-0.13	0.06	0.19	-0.07	-0.78	-1.15	-0.36	0.18	0.67
J=18	0.22	-0.08	-0.06	0.21	0.35	0.44	0.44	-0.17	-0.15	0.53	0.93	1.28
J=24	0.28	-0.01	0.10	0.41	0.56	0.58	0.46	-0.02	0.20	0.90	1.34	1.48
J=30	0.21	0.14	0.26	0.59	0.67	0.64	0.44	0.30	0.56	1.34	1.57	1.58

Panel D: FF5 model GRS: F=1.86*												
	α (%)						$t(\alpha)$					
J=6	1.40	0.15	-0.24	-0.08	0.13	0.25	2.57	0.32	-0.73	-0.27	0.57	1.19
J=12	0.14	-0.30	-0.37	0.03	0.24	0.39	0.26	-0.63	-0.90	0.10	0.81	1.41
J=18	0.43	0.07	0.10	0.43	0.60	0.71	0.84	0.14	0.23	1.08	1.66	2.11
J=24	0.64	0.23	0.38	0.75	0.92	0.91	1.02	0.47	0.83	1.73	2.26	2.33
J=30	0.71	0.42	0.61	0.97	1.02	0.99	1.35	0.86	1.33	2.22	2.38	2.38
Panel E: YCAPM model GRS: F=1.39*												
	α (%)						$t(\alpha)$					
J=6	0.78	-0.20	-0.48	-0.39	-0.11	0.01	1.37	-0.35	-1.23	-1.45	-0.48	0.05
J=12	-0.44	-0.60	-0.75	-0.36	-0.10	0.04	-0.69	-1.01	-1.86	-1.11	-0.32	0.14
J=18	-0.11	-0.40	-0.27	0.05	0.23	0.23	-0.24	-0.73	-0.60	0.13	0.65	0.71
J=24	-0.11	-0.19	0.00	0.32	0.39	0.33	-0.16	-0.37	0.01	0.74	0.97	0.88
J=30	-0.06	-0.09	0.12	0.37	0.40	0.36	-0.12	-0.18	0.25	0.87	0.96	0.91
Panel F: YFF3 model GRS: F=1.36												
	α (%)						$t(\alpha)$					
J=6	0.74	-0.25	-0.54	-0.44	-0.17	-0.03	1.29	-0.44	-1.39	-1.64	-0.73	-0.14
J=12	-0.49	-0.69	-0.82	-0.42	-0.15	0.00	-0.77	-1.16	-2.04	-1.31	-0.51	0.01
J=18	-0.15	-0.49	-0.36	-0.03	0.17	0.20	-0.31	-0.90	-0.83	-0.08	0.48	0.59
J=24	-0.19	-0.32	-0.10	0.24	0.33	0.29	-0.29	-0.62	-0.22	0.55	0.81	0.75
J=30	-0.17	-0.17	0.03	0.31	0.36	0.34	-0.36	-0.37	0.07	0.72	0.86	0.84
Panel G: YFF4 model GRS: F=1.29												
	α (%)						$t(\alpha)$					
J=6	0.29	-0.49	-0.68	-0.53	-0.20	-0.07	0.51	-0.86	-1.71	-1.85	-0.84	-0.31
J=12	-0.76	-0.89	-0.92	-0.47	-0.20	-0.07	-1.20	-1.48	-2.12	-1.36	-0.67	-0.23
J=18	-0.49	-0.64	-0.43	-0.08	0.10	0.13	-0.96	-1.15	-0.93	-0.19	0.27	0.36
J=24	-0.42	-0.42	-0.19	0.16	0.26	0.22	-0.61	-0.79	-0.39	0.35	0.60	0.54
J=30	-0.45	-0.33	-0.09	0.23	0.29	0.27	-0.99	-0.66	-0.18	0.50	0.64	0.62
Panel H: YFF5 model GRS: F=1.69*												
	α (%)						$t(\alpha)$					
J=6	0.70	-0.38	-0.59	-0.39	-0.07	0.07	1.20	-0.68	-1.53	-1.41	-0.30	0.30
J=12	-0.58	-0.81	-0.80	-0.30	-0.01	0.14	-0.91	-1.37	-1.92	-0.91	-0.05	0.51
J=18	-0.26	-0.48	-0.26	0.14	0.36	0.41	-0.54	-0.87	-0.59	0.37	0.99	1.20
J=24	-0.07	-0.18	0.10	0.51	0.63	0.56	-0.11	-0.35	0.22	1.17	1.53	1.43
J=30	0.05	-0.05	0.27	0.62	0.65	0.63	0.11	-0.11	0.57	1.39	1.48	1.49

Note: This table reports the pricing errors (α) for the thirty momentum strategies with constant risk premium. $t(\alpha)$ is corrected with Newey and West (1978) procedure with one lag. The GRS F-statistics are also shown in the table. The null hypothesis of GRS test is that the pricing errors are jointly zero. *, ** and *** denotes 10%, 5% and 1% significance respectively. J is the formation period to rank commodities. K is the holding period for the winners and losers portfolios. One period refers to two months. The sample starts from September 1970 in order to use balanced bimonthly portfolio returns. The sample ends in September 2020. *CAPM* refers to the model only including *MKT* factor. *FF3* refers to the model including *MKT* , *SMB* and *HML* factors. *FF4* refers to the model including *MKT* , *SMB* , *HML* and *MOM* factors. *FF5* refers to the model including *MKT* , *SMB* , *HML* , *RMW* and *CMA* factors. *YCAPM, YFF3, YFF4* and *YFF5* respectively refer to the models including HML_y factor in addition to the factors in *CAPM, FF3, FF4* and *YFF5*.

Table B.5

Fama-Macbeth cross-sectional regressions for spot momentum strategies (%).

Model	λ_{MKT}	λ_{SMB}	λ_{HML}	λ_{MOM}	λ_{RMW}	λ_{CMA}	λ_{HML_y}	α	Avg. R^2
YF							1.01	0.11	22.27
							(0.78)	(0.28)	
CAPM	0.20							0.37*	15.06
	(0.08)							(1.65)	
FF3	-4.06*	-3.51*	-1.81					0.44**	44.91
	(-1.65)	(-1.71)	(-1.59)					(1.99)	
FF4	2.01	-4.64**	-1.85	6.34***				0.07	62.05
	(0.78)	(-2.41)	(-1.62)	(3.12)				(0.30)	
FF5	-2.59	-1.39	-0.72		2.45**	-2.04**		-0.19	60.71
	(-1.11)	(-1.25)	(-0.69)		(2.06)	(-2.39)		(-0.81)	
YCAPM	3.17						1.50	0.15	37.62
	(0.97)						(0.98)	(0.43)	
YFF3	2.56	-3.84*	-1.95*				2.81**	-0.16	57.27
	(0.97)	(-1.93)	(-1.69)				(2.34)	(-0.62)	
YFF4	1.41	-4.75**	-1.82	7.49***			-1.37	0.154	66.26
	(0.57)	(-2.40)	(-1.59)	(3.06)			(-1.06)	(0.72)	
YFF5	1.94	-1.65	-1.81		-0.12	-1.93**	2.98**	-0.30	66.94
	(0.69)	(-1.49)	(-1.55)		(-0.12)	(-2.27)	(2.58)	(-1.21)	

Note: This table reports the cross-sectional regression results of the Fama and MacBeth (1973) two-step procedure for the thirty momentum strategies: $WML_{J-K,t} = \lambda_{0,t} + \widehat{\beta}'_{J-K,f}\lambda_{f,t} + \varepsilon_{J-K,t}$, where $WML_{J-K,t}$ refers to the excess return at time t of the winners-losers portfolios with formation period of J and holding period of K. $\widehat{\beta}'_{i,f}$ is the estimated beta with the time-series regressions (the first step) of Fama and MacBeth (1973). $\lambda_{f,t}$ is the risk premia of risk factor f. $\lambda_{0,t}$ and $\varepsilon_{J-K,t}$ are the intercept and error term of the cross-sectional regressions. The final estimates of $\lambda_{f,t}$ and $\lambda_{0,t}$ are average value of their time-series estimates. That is $\hat{\lambda}_0 = \sum_{t=1}^{T}\hat{\lambda}_{0,t}/T$ and $\hat{\lambda}_f = \sum_{t=1}^{T}\hat{\lambda}_{f,t}/T$. The t-statistics are corrected with Newey and West (1987) procedure with one lag. *, ** and *** denote the significance at the 10%, 5% and 1% levels respectively. The R^2 is the average value of the R_t^2 of the T cross-sectional regressions. That is $R^2 = \sum_{t=1}^{T}R_t^2/T$. The sample ranges from September 1970 to September 2020. *YF* refers to the model only including HML_y factor. *CAPM* refers to the model only including MKT factor. *FF3* refers to the model including MKT, *SMB* and *HML* factors. *FF4* refers to the model including MKT, *SMB*, *HML* and *MOM* factors. *FF5* refers to the model including MKT, *SMB*, *HML*, *RMW* and *CMA* factors. *YCAPM, YFF3, YFF4* and *YFF5* respectively refer to the models including HML_y factor in addition to the factors in *CAPM, FF3, FF4* and *YFF5*.

Table B.6

Fama-Macbeth cross-sectional regressions of spot momentum strategy returns on percentage yield and β on factors (%).

Model	λ_{MKT}	λ_{SMB}	λ_{HML}	λ_{MOM}	λ_{RMW}	λ_{CMA}	λ_{HML_y}	λ_{Yield}	α	Avg. R^2
Yield								7.84	-0.01	27.11
								(0.55)	(-0.03)	
YF+Yield							-0.20	7.00	0.20	40.70
							(-0.14)	(0.48)	(0.61)	
CAPM+Yield	2.78							11.30	0.23	40.36
	(1.01)							(0.73)	(0.91)	
FF3+Yield	0.92	-3.65*	-2.09*					19.10	0.13	60.95
	(0.36)	(-1.92)	(-1.88)					(1.45)	(0.56)	
FF4+Yield	1.26	-4.33**	-2.57**	4.52**				15.2	0.092	70.41
	(0.49)	(-2.50)	(-2.12)	(2.24)				(1.22)	(0.39)	
FF5+Yield	0.09	-0.27	-1.98*		-0.37	-2.46***		15.10	-0.16	72.23
	(0.03)	(-0.23)	(-1.70)		(-0.32)	(-2.75)		(1.08)	(-0.72)	
YCAPM+Yield	3.63						0.67	8.35	0.20	52.72
	(1.16)						(0.45)	(0.55)	(0.64)	
YFF3+Yield	2.14	-3.95**	-2.34**				0.66	15.80	0.03	67.57
	(0.84)	(-2.24)	(-2.01)				(0.59)	(1.22)	(0.12)	
YFF4+Yield	0.68	-4.48**	-2.57**	5.90**			-1.87	13.50	0.28	74.05
	(0.28)	(-2.58)	(-2.16)	(2.58)			(-1.50)	(1.07)	(1.23)	
YFF5+Yield	1.10	-0.77	-2.38**		-0.94	-2.36***	0.56	14.00	-0.13	76.19
	(0.39)	(-0.66)	(-1.99)		(-0.89)	(-2.63)	(0.55)	(1.00)	(-0.56)	

Note: This table reports the cross-sectional regression of the thirty momentum strategy returns on $\hat{\beta}_{i,f}^{'}$ of risk factors and the percentage yield. $\hat{\beta}_{i,f}^{'}$ is the estimated beta with the time-series regressions (the first step) of Fama and MacBeth (1973). λ_f is the risk premia of risk factor f and percentage yield. λ_0 is the intercept of the cross-sectional regressions. The final estimates of λ_f and λ_0 are average value of their time-series estimates. That is $\hat{\lambda}_0 = \sum_{t=1}^{T} \hat{\lambda}_{0,t} \big/ T$ and $\hat{\lambda}_f = \sum_{t=1}^{T} \hat{\lambda}_{f,t} \big/ T$. The t-statistics are corrected with Newey and West (1987) procedure with one lag. *, ** and *** denote the significance at the 10%, 5% and 1% levels respectively. The R^2 is the average value of the R_t^2 of the T cross-sectional regressions. That is $R^2 = \sum_{t=1}^{T} R_t^2 \big/ T$. The sample ranges from September 1970 to September 2020. *Yield* model refers to the one only including the percentage yield. YF refers to the model only including HML_y factor. CAPM refers to the model only including MKT factor. FF3 refers to the model including MKT, SMB and HML factors. FF4 refers to the model including MKT, SMB, HML and MOM factors. FF5 refers to the model including MKT, SMB, HML, RMW and CMA factors. YCAPM, YFF3, YFF4 and YFF5 respectively refer to the models including HML_y factor in addition to the factors in CAPM, FF3, FF4 and YFF5.

Table B.7

Fama-Macbeth cross-sectional regressions for 900 futures momentum strategies (%).

Model	λ_{MKT}	λ_{SMB}	λ_{HML}	λ_{MOM}	λ_{RMW}	λ_{CMA}	λ_{HML_y}	α	Avg. R^2
YF							0.08	0.24	17.57
							(0.07)	(0.74)	
CAPM	-0.19							0.25	15.39
	(-0.08)							(1.43)	
FF3	-0.80	-3.59*	-1.18					0.30*	46.02
	(-0.59)	(-1.78)	(-0.94)					(1.79)	
FF4	-0.94	-5.25***	-1.88	5.25**				0.05	58.56
	(-0.68)	(-2.93)	(-1.36)	(2.52)				(0.41)	
FF5	-1.79	-4.74***	-1.24		2.26**	-0.66		0.12	58.93
	(-1.23)	(-3.84)	(-1.00)		(2.05)	(-1.00)		(0.83)	
YCAPM	-0.15						0.07	0.24	34.03
	(-0.06)						(0.06)	(0.91)	
YFF3	-1.45	-5.12***	-2.68*				1.77*	0.01	55.81
	(-1.00)	(-2.92)	(-1.74)				(1.83)	(0.06)	
YFF4	-0.89	-5.22***	-1.79	5.46**			-0.62	0.06	61.28
	(-0.65)	(-2.98)	(-1.39)	(2.37)			(-0.56)	(0.48)	
YFF5	-1.12	-4.83***	-3.00**		0.08	-1.02	1.98**	0.03	63.71
	(-0.85)	(-3.86)	(-2.02)		(0.10)	(-1.54)	(2.16)	(0.21)	

Note: Panel A reports the cross-sectional regression results of the Fama and MacBeth (1973) two-step procedure for the thirty momentum strategies: $WML_{J-K,t} = \lambda_{0,t} + \widehat{\beta}'_{J-K,f}\lambda_{f,t} + \varepsilon_{J-K,t}$, where $WML_{J-K,t}$ refers to the excess return at time t of the winners-losers portfolios with formation period of J and holding period of K. $\widehat{\beta}'_{i,f}$ is the estimated beta with the time-series regressions (the first step) of Fama and MacBeth (1973). $\lambda_{f,t}$ is the risk premia of risk factor f. $\lambda_{0,t}$ and $\varepsilon_{J-K,t}$ are the intercept and error term of the cross-sectional regressions. The final estimates of $\lambda_{f,t}$ and $\lambda_{0,t}$ are average value of their time-series estimates. That is $\widehat{\lambda}_0 = \sum_{t=1}^{T}\widehat{\lambda}_{0,t}/T$ and $\widehat{\lambda}_f = \sum_{t=1}^{T}\widehat{\lambda}_{f,t}/T$. The t-statistics are corrected with Newey and West (1987) procedure with one lag. *, ** and *** denote the significance at the 10%, 5% and 1% levels respectively. The R^2 is the average value of the R_t^2 of the T cross-sectional regressions. Panel B reports the cross-sectional regression of the thirty momentum strategy returns on $\widehat{\beta}'_{i,f}$ of risk factors and the percentage yield. That is $R^2 = \sum_{t=1}^{T}R_t^2/T$. The sample ranges from September 1970 to September 2020. *YF* refers to the model only including HML_y factor. *CAPM* refers to the model only including *MKT* factor. *FF3* refers to the model including *MKT*, *SMB* and *HML* factors. *FF4* refers to the model including *MKT*, *SMB*, *HML* and *MOM* factors. *FF5* refers to the model including *MKT*, *SMB*, *HML*, *RMW* and *CMA* factors. *YCAPM, YFF3, YFF4* and *YFF5* respectively refer to the models including HML_y factor in addition to the factors in *CAPM, FF3, FF4* and *YFF5*.

Table B.8

Fama-Macbeth cross-sectional regressions for futures momentum strategies with rolling window of 6 years (%).

Model	λ_{MKT}	λ_{SMB}	λ_{HML}	λ_{MOM}	λ_{RMW}	λ_{CMA}	λ_{HML_y}	α	Avg. R^2
YF							1.69	0.09	21.68
							(1.63)	(0.28)	
CAPM	-1.18							0.50	22.35
	(-0.87)							(1.55)	
FF3	-0.76	-0.35	1.62**					0.14	45.83
	(-0.64)	(-0.55)	(2.28)					(0.46)	
FF4	-0.49	-0.37	1.32*	0.08				-0.06	55.84
	(-0.42)	(-0.64)	(1.75)	(0.07)				(-0.22)	
FF5	-1.49	-0.65	1.38*		-0.43	0.72		-0.05	63.21
	(-1.04)	(-1.00)	(1.81)		(-0.62)	(1.49)		(-0.19)	
YCAPM	-0.54						0.98	0.26	37.16
	(-0.45)						(0.93)	(0.85)	
YFF3	0.05	-0.23	1.30*				1.16	0.10	55.46
	(0.05)	(-0.36)	(1.70)				(1.08)	(0.36)	
YFF4	0.65	-0.24	0.63	0.84			1.84*	-0.10	63.36
	(0.62)	(-0.39)	(0.77)	(0.68)			(1.72)	(-0.40)	
YFF5	-0.64	-0.56	1.10		-0.94	0.85*	0.29	0.17	69.38
	(-0.52)	(-0.95)	(1.55)		(-1.37)	(1.86)	(0.27)	(0.68)	

Note: Panel A reports the cross-sectional regression results of the Fama and MacBeth (1973) two-step procedure with for the thirty momentum strategies: $WML_{J-K,t} = \lambda_{0,t} + \widehat{\beta}'_{J-K,f}\lambda_{f,t} + \varepsilon_{J-K,t}$, where $WML_{J-K,t}$ refers to the excess return at time t of the winners-losers portfolios with formation period of J and holding period of K. $\widehat{\beta}'_{i,f}$ is the estimated beta with the time-series regressions (the first step) of Fama and MacBeth (1973) with a rolling window of 6 years. $\lambda_{f,t}$ is the risk premia of risk factor f. $\lambda_{0,t}$ and $\varepsilon_{J-K,t}$ are the intercept and error term of the cross-sectional regressions. The final estimates of $\lambda_{f,t}$ and $\lambda_{0,t}$ are average value of their time-series estimates. That is $\widehat{\lambda}_0 = \sum_{t=1}^{T}\widehat{\lambda}_{0,t}/T$ and $\widehat{\lambda}_f = \sum_{t=1}^{T}\widehat{\lambda}_{f,t}/T$. The t-statistics are corrected with Newey and West (1987) procedure with one lag. *, ** and *** denote the significance at the 10%, 5% and 1% levels respectively. The R^2 is the average value of the R_t^2 of the T cross-sectional regressions. Panel B reports the cross-sectional regression of the thirty momentum strategy returns on $\widehat{\beta}'_{i,f}$ of risk factors and the percentage yield. That is $R^2 = \sum_{t=1}^{T}R_t^2/T$. The sample ranges from September 1976 to September 2020. *YF* refers to the model only including HML_y factor. *CAPM* refers to the model only including MKT factor. *FF3* refers to the model including MKT, SMB and HML factors. *FF4* refers to the model including MKT, SMB, HML and MOM factors. *FF5* refers to the model including MKT, SMB, HML, RMW and CMA factors. *YCAPM, YFF3, YFF4* and *YFF5* respectively refer to the models including HML_y factor in addition to the factors in *CAPM, FF3, FF4* and *YFF5*.

Table B.9

Fama-Macbeth cross-sectional regressions for futures momentum strategies with rolling window of 10 years (%).

Model	λ_{MKT}	λ_{SMB}	λ_{HML}	λ_{MOM}	λ_{RMW}	λ_{CMA}	λ_{HML_y}	α	Avg. R^2
YF							0.42	0.49	19.61
							(0.44)	(1.37)	
CAPM	0.91							0.31	23.91
	(0.84)							(0.91)	
FF3	-0.30	1.18	2.00**					0.18	45.17
	(-0.22)	(1.18)	(2.13)					(0.55)	
FF4	0.84	1.28	0.70	2.79				-0.08	56.16
	(0.66)	(1.44)	(0.69)	(1.57)				(-0.27)	
FF5	0.12	0.52	1.74*		-0.64	-0.11		0.03	62.59
	(0.08)	(0.59)	(1.90)		(-0.93)	(-0.23)		(0.11)	
YCAPM	2.71**						0.44	0.20	39.98
	(2.07)						(0.38)	(0.61)	
YFF3	0.62	0.48	0.08				0.90	0.18	56.32
	(0.52)	(0.50)	(0.08)				(0.76)	(0.56)	
YFF4	1.15	0.57	-1.38	3.46**			0.86	-0.02	64.59
	(0.87)	(0.64)	(-1.14)	(2.08)			(0.61)	(-0.07)	
YFF5	0.58	-0.22	0.38		-0.44	-0.31	0.61	-0.03	69.65
	(0.43)	(-0.28)	(0.41)		(-0.64)	(-0.58)	(0.56)	(-0.11)	

Note: Panel A reports the cross-sectional regression results of the Fama and MacBeth (1973) two-step procedure with for the thirty momentum strategies: $WML_{J-K,t} = \lambda_{0,t} + \widehat{\beta}'_{J-K,f}\lambda_{f,t} + \varepsilon_{J-K,t}$, where $WML_{J-K,t}$ refers to the excess return at time t of the winners-losers portfolios with formation period of J and holding period of K. $\widehat{\beta}'_{i,f}$ is the estimated beta with the time-series regressions (the first step) of Fama and MacBeth (1973) with a rolling window of 10 years. $\lambda_{f,t}$ is the risk premia of risk factor f. $\lambda_{0,t}$ and $\varepsilon_{J-K,t}$ are the intercept and error term of the cross-sectional regressions. The final estimates of $\lambda_{f,t}$ and $\lambda_{0,t}$ are average value of their time-series estimates. That is $\widehat{\lambda}_0 = \sum_{t=1}^{T}\widehat{\lambda}_{0,t}/T$ and $\widehat{\lambda}_f = \sum_{t=1}^{T}\widehat{\lambda}_{f,t}/T$. The t-statistics are corrected with Newey and West (1987) procedure with one lag. *, ** and *** denote the significance at the 10%, 5% and 1% levels respectively. The R^2 is the average value of the R_t^2 of the T cross-sectional regressions. Panel B reports the cross-sectional regression of the thirty momentum strategy returns on $\widehat{\beta}'_{i,f}$ of risk factors and the percentage yield. That is $R^2 = \sum_{t=1}^{T}R_t^2/T$. The sample ranges from September 1980 to September 2020. *Yield* model refers to the one only including the percentage yield. *YF* refers to the model only including HML_y factor. *CAPM* refers to the model only including MKT factor. *FF3* refers to the model including MKT, SMB and HML factors. *FF4* refers to the model including MKT, SMB, HML and MOM factors. *FF5* refers to the model including MKT, SMB, HML, RMW and CMA factors. *YCAPM, YFF3, YFF4* and *YFF5* respectively refer to the models including HML_y factor in addition to the factors in *CAPM, FF3, FF4* and *YFF5*

Appendix C. Figures

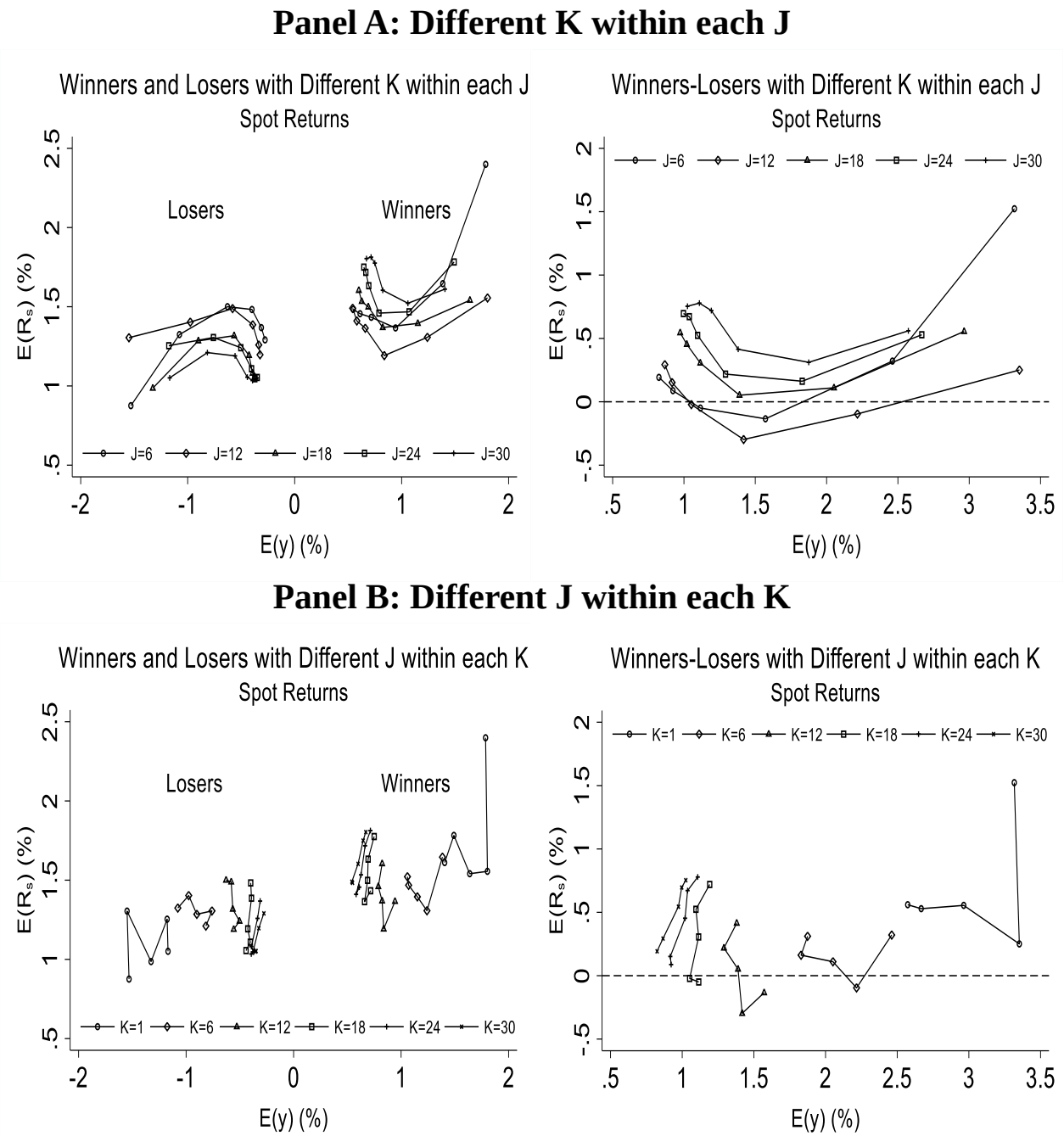
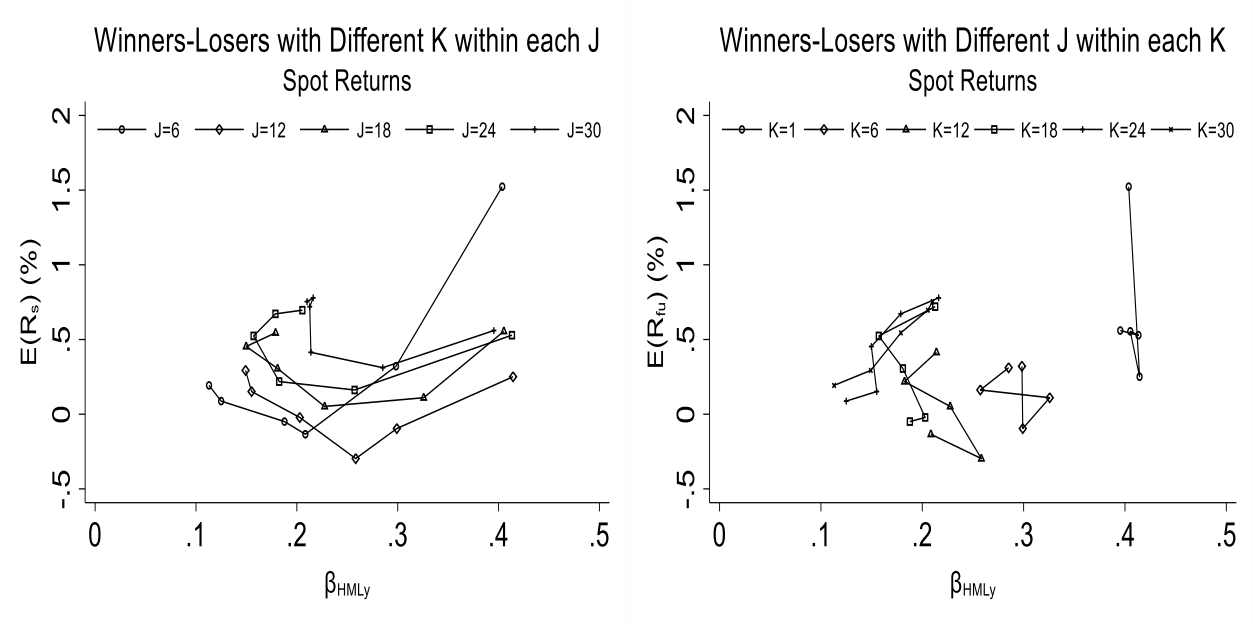


Fig. C.1. Return-yield relationship cross different spot momentum strategies. *Note:* This Figure shows the cross-sectional relationships between bimonthly percentage yields and average spot returns of winners, losers, winners-losers portfolios within each formation and holding groups. The percentage yield of winners, losers and winners-losers portfolios are constructed in the same way of the construction of portfolios. $E\left(R_{fu}\right)$, $E\left(R_{s}\right)$ and $E\left(cg\right)$ refers to bimonthly average futures returns, spot returns, and capital gains. Sample ranges from November 1970 to September 2020. J is the formation period to rank commodities. K is the holding period for the winners and losers portfolios. One period refers to two months. Panel A connects the portfolios with different holding periods within formation groups. Panel B connects the portfolios with different formation periods within holding groups.

Panel A: Average returns and risk loadings on yield factor



Panel B: Realized and Predicted Average returns

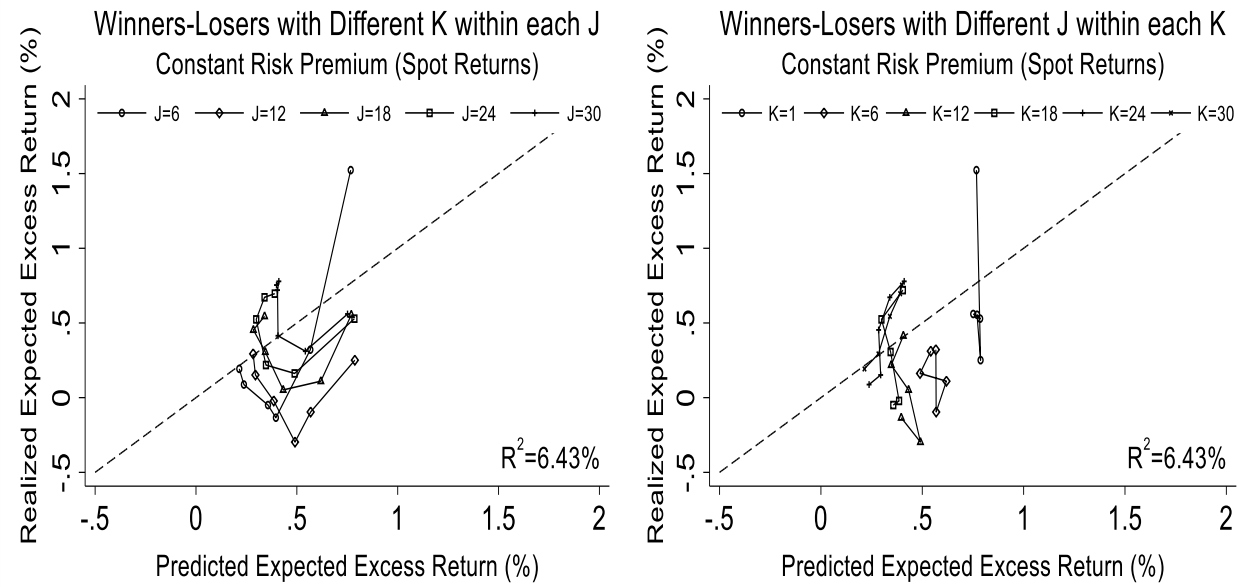


Fig. C.2. Risk loadings and Predicted average spot returns with constant risk premiums. *Note:* The predicted expected returns are calculated with $E\left(WML_{J-K}\right)=\widehat{\beta}_{i,f}^{'}\widehat{\lambda}_{f}$, where $\widehat{\beta}_{i,f}^{'}$ is the estimated beta with the time-series regressions (the first step) of Fama and MacBeth (1973). $\widehat{\lambda}_{f}$ is the average return of risk factors. The realized expected returns are the average return in the sample from November 1970 to September 2020. The R^2 is calculated with the cross-sectional regression of the realized expected returns of the thirty winners-losers portfolios on the estimated risk loadings $\widehat{\beta}_{i,f}^{'}$. J is the formation period to rank commodities. K is the holding period for the winners and losers portfolios. One period refers to two months.

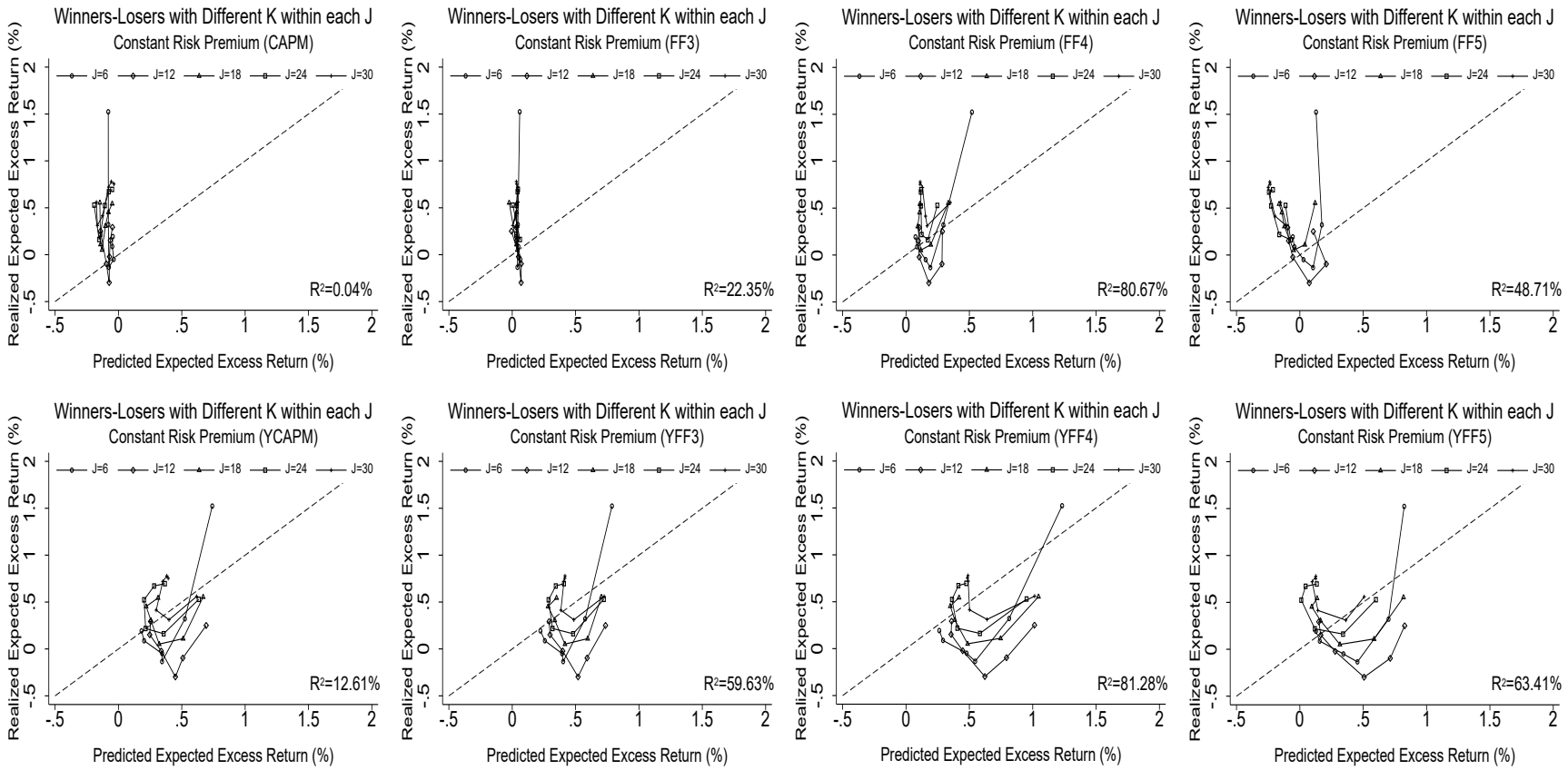


Fig. C.3. Realized and Predicted average returns with constant risk premiums within formation groups for spot momentum strategies. *Note:* The predicted expected returns are calculated with $E\left(WML_{J-K}\right)=\widehat{\beta}_{i,f}^{'}\widehat{\lambda}_{f}$, where $\widehat{\beta}_{i,f}^{'}$ is the estimated beta with the time-series regressions (the first step) of Fama and MacBeth (1973). $\widehat{\lambda}_{f}$ is the average return of risk factors. The realized expected returns are the average return in the sample from November 1970 to September 2020. The R^2 is calculated with the cross-sectional regression of the realized expected returns of winners-losers portfolios on the estimated risk loadings $\widehat{\beta}_{i,f}^{'}$. J is the formation period to rank commodities. K is the holding period for the winners and losers portfolios. One period refers to two months. *CAPM* refers to the model only including *MKT* factor. *FF3* refers to the model including *MKT* , *SMB* and *HML* factors. *FF4* refers to the model including *MKT* , *SMB* , *HML* and *MOM* factors. *FF5* refers to the model including *MKT* , *SMB* , *HML* , *RMW* and *CMA* factors. *YCAPM, YFF3, YFF4* and *YFF5* respectively refer to the models including HML_y factor in addition to the factors in *CAPM, FF3, FF4* and *YFF5.*

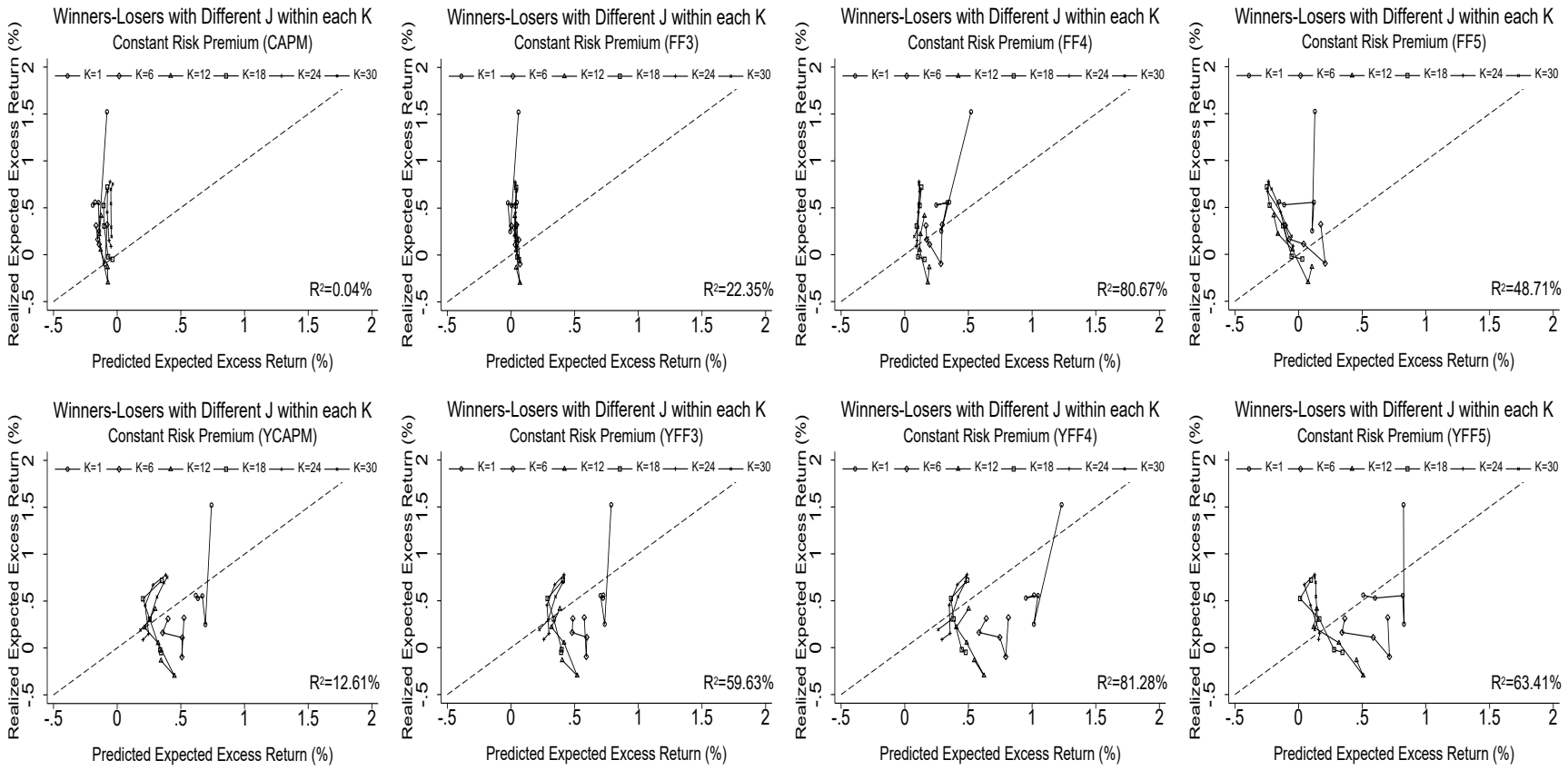


Fig. C.4. Realized and Predicted average returns with constant risk premiums within holding groups for spot momentum strategies. *Note:* The predicted expected returns are calculated with $E\left(WML_{J-K}\right)=\widehat{\beta}_{i,f}^{'}\widehat{\lambda}_{f}$, where $\widehat{\beta}_{i,f}^{'}$ is the estimated beta with the time-series regressions (the first step) of Fama and MacBeth (1973). $\widehat{\lambda}_{f}$ is the average return of risk factors. The realized expected returns are the average return in the sample from November 1970 to September 2020. The R^2 is calculated with the cross-sectional regression of the realized expected returns of winners-losers portfolios on the estimated risk loadings $\widehat{\beta}_{i,f}^{'}$. J is the formation period to rank commodities. K is the holding period for the winners and losers portfolios. One period refers to two months. *CAPM* refers to the model only including *MKT* factor. *FF3* refers to the model including *MKT*, *SMB* and *HML* factors. *FF4* refers to the model including *MKT*, *SMB*, *HML* and *MOM* factors. *FF5* refers to the model including *MKT*, *SMB*, *HML*, *RMW* and *CMA* factors. *YCAPM, YFF3, YFF4* and *YFF5* respectively refer to the models including HML_y factor in addition to the factors in *CAPM, FF3, FF4* and *YFF5*.

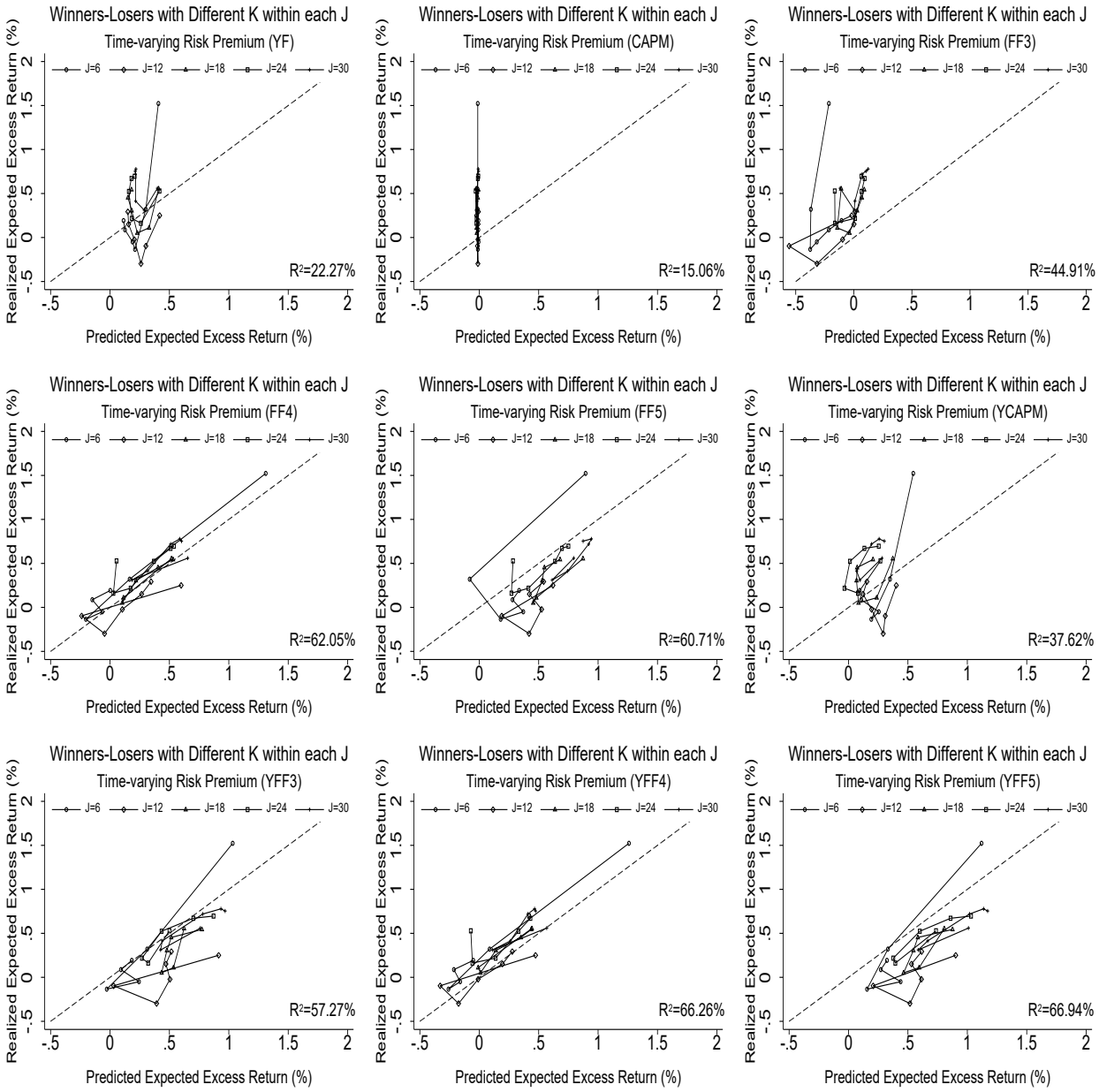


Fig. C.5. Realized and Predicted average spot returns with time-varying risk premiums within formation groups. *Note:* The predicted expected returns are calculated with $E\left(WML_{J-K}\right)=\widehat{\beta}_{i,f}^{'}\widehat{\lambda}_{f}$, where $\widehat{\beta}_{i,f}^{'}$ is the estimated beta with the time-series regressions (the first step) of Fama and MacBeth (1973). $\widehat{\lambda}_{f}$ is the estimated risk premia of risk factors with the cross-sectional regressions (the second step) of Fama and MacBeth (1973). The realized expected returns are the average return in the sample from November 1970 to September 2020. The R^2 is the average value of the R_t^2 of the T cross-sectional regressions. That is $R^2=\sum_{t=1}^{T}R_t^2\Big/T$. J is the formation period to rank commodities. K is the holding period for the winners and losers portfolios. One period refers to two months. *YF* refers to the model only including HML_y factor. *CAPM* refers to the model only including *MKT* factor. *FF3* refers to the model including *MKT* , *SMB* and *HML* factors. *FF4* refers to the model including *MKT* , *SMB* , *HML* and *MOM* factors. *FF5* refers to the model including *MKT* , *SMB* , *HML* , *RMW* and *CMA* factors. *YCAPM, YFF3, YFF4* and *YFF5* respectively refer to the models including HML_y factor in addition to the factors in *CAPM, FF3, FF4* and *YFF5*.

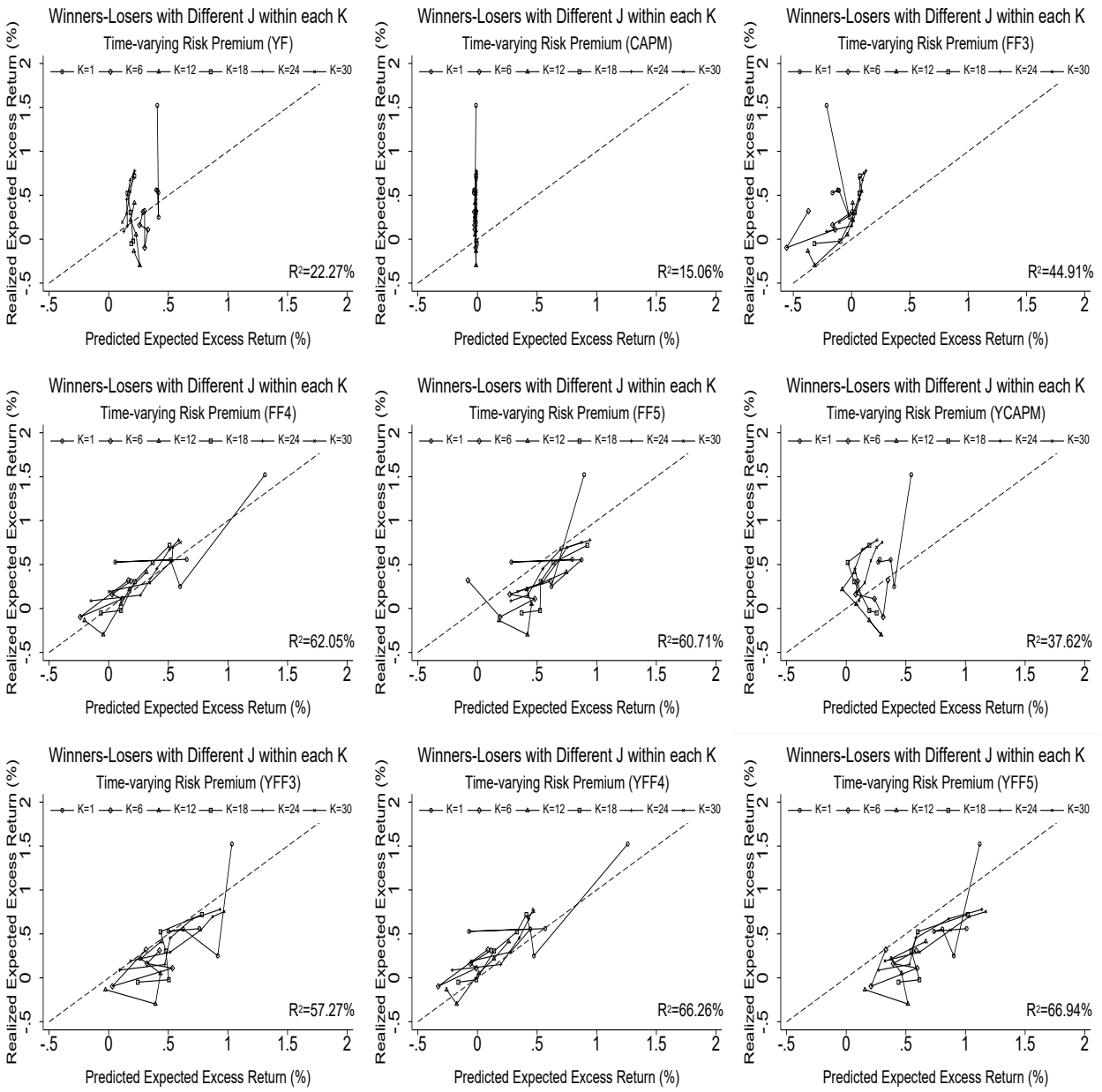


Fig. C.6. Realized and Predicted average spot returns with time-varying risk premiums within holding groups. *Note:* The predicted expected returns are calculated with $E\left(WML_{J-K}\right)=\widehat{\beta}_{i,f}^{'}\widehat{\lambda}_{f}$, where $\widehat{\beta}_{i,f}^{'}$ is the estimated beta with the time-series regressions (the first step) of Fama and MacBeth (1973). $\widehat{\lambda}_{f}$ is the estimated risk premia of risk factors with the cross-sectional regressions (the second step) of Fama and MacBeth (1973). The realized expected returns are the average return in the sample from November 1970 to September 2020. The R^2 is the average value of the R_t^2 of the T cross-sectional regressions. That is $R^2=\sum_{t=1}^{T}R_t^2\big/T$. J is the formation period to rank commodities. K is the holding period for the winners and losers portfolios. One period refers to two months. *YF* refers to the model only including HML_y factor. *CAPM* refers to the model only including *MKT* factor. *FF3* refers to the model including *MKT* , *SMB* and *HML* factors. *FF4* refers to the model including *MKT* , *SMB* , *HML* and *MOM* factors. *FF5* refers to the model including *MKT* , *SMB* , *HML* , *RMW* and *CMA* factors. *YCAPM, YFF3, YFF4* and *YFF5* respectively refer to the models including HML_y factor in addition to the factors in *CAPM, FF3, FF4* and *YFF5*.

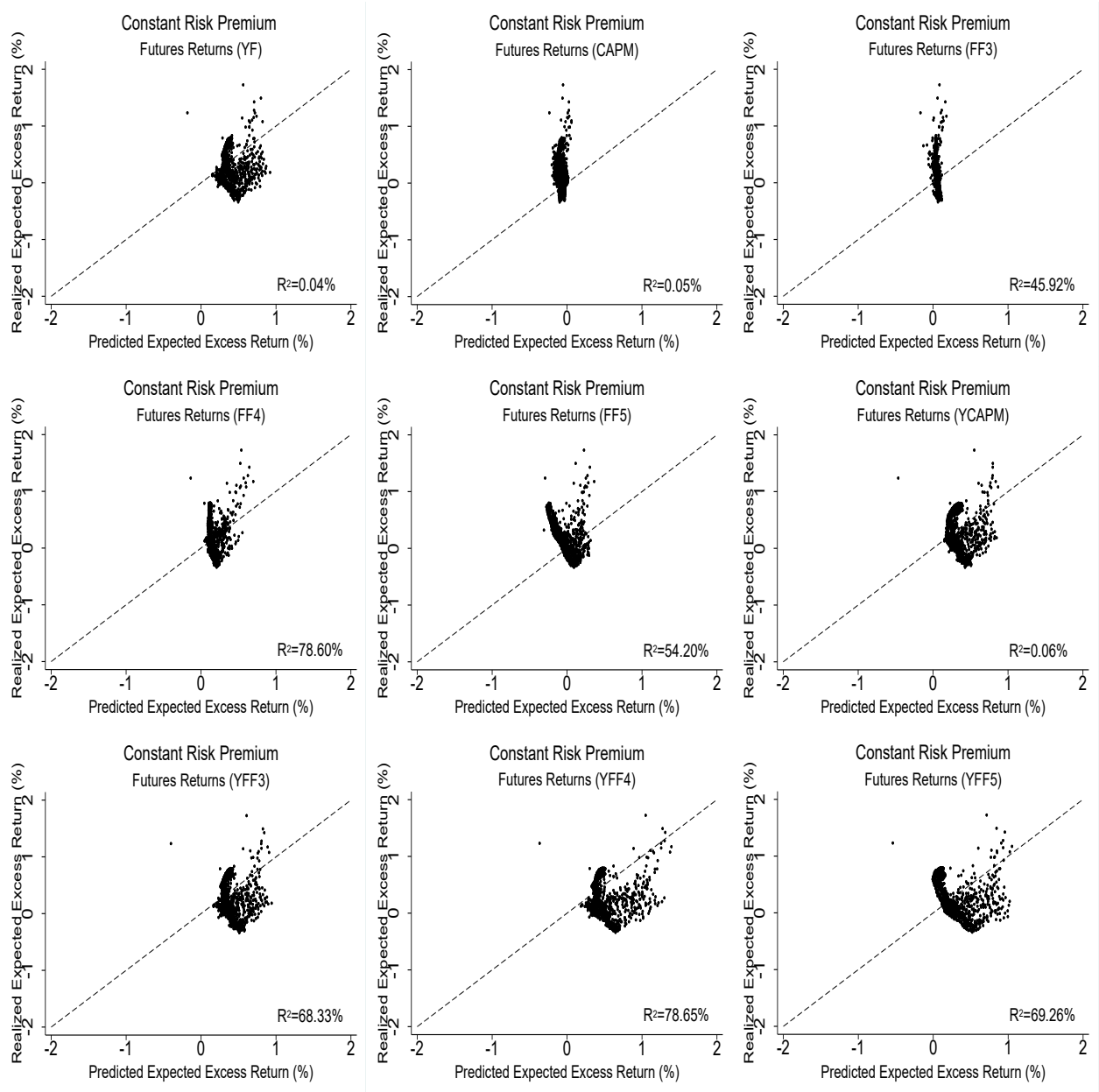


Fig. C.7. Realized and Predicted average returns with constant risk premiums for 900 futures momentum strategies. *Note:* The predicted expected returns are calculated with $E\left(WML_{J-K}\right)=\widehat{\beta}_{i,f}^{'}\widehat{\lambda}_{f}$, where $\widehat{\beta}_{i,f}^{'}$ is the estimated beta with the time-series regressions (the first step) of Fama and MacBeth (1973). $\widehat{\lambda}_{f}$ is the average return of risk factors. The realized expected returns are the average return in the sample from November 1970 to September 2020. The R^2 is calculated with the cross-sectional regression of the realized expected returns of winners-losers portfolios on the estimated risk loadings $\widehat{\beta}_{i,f}^{'}$. J is the formation period to rank commodities. K is the holding period for the winners and losers portfolios. One period refers to two months. *YF* refers to the model only including HML_y factor. *CAPM* refers to the model only including *MKT* factor. *FF3* refers to the model including *MKT* , *SMB* and *HML* factors. *FF4* refers to the model including *MKT* , *SMB* , *HML* and *MOM* factors. *FF5* refers to the model including *MKT* , *SMB* , *HML* , *RMW* and *CMA* factors. *YCAPM, YFF3, YFF4* and *YFF5* respectively refer to the models including HML_y factor in addition to the factors in *CAPM, FF3, FF4* and *YFF5*.

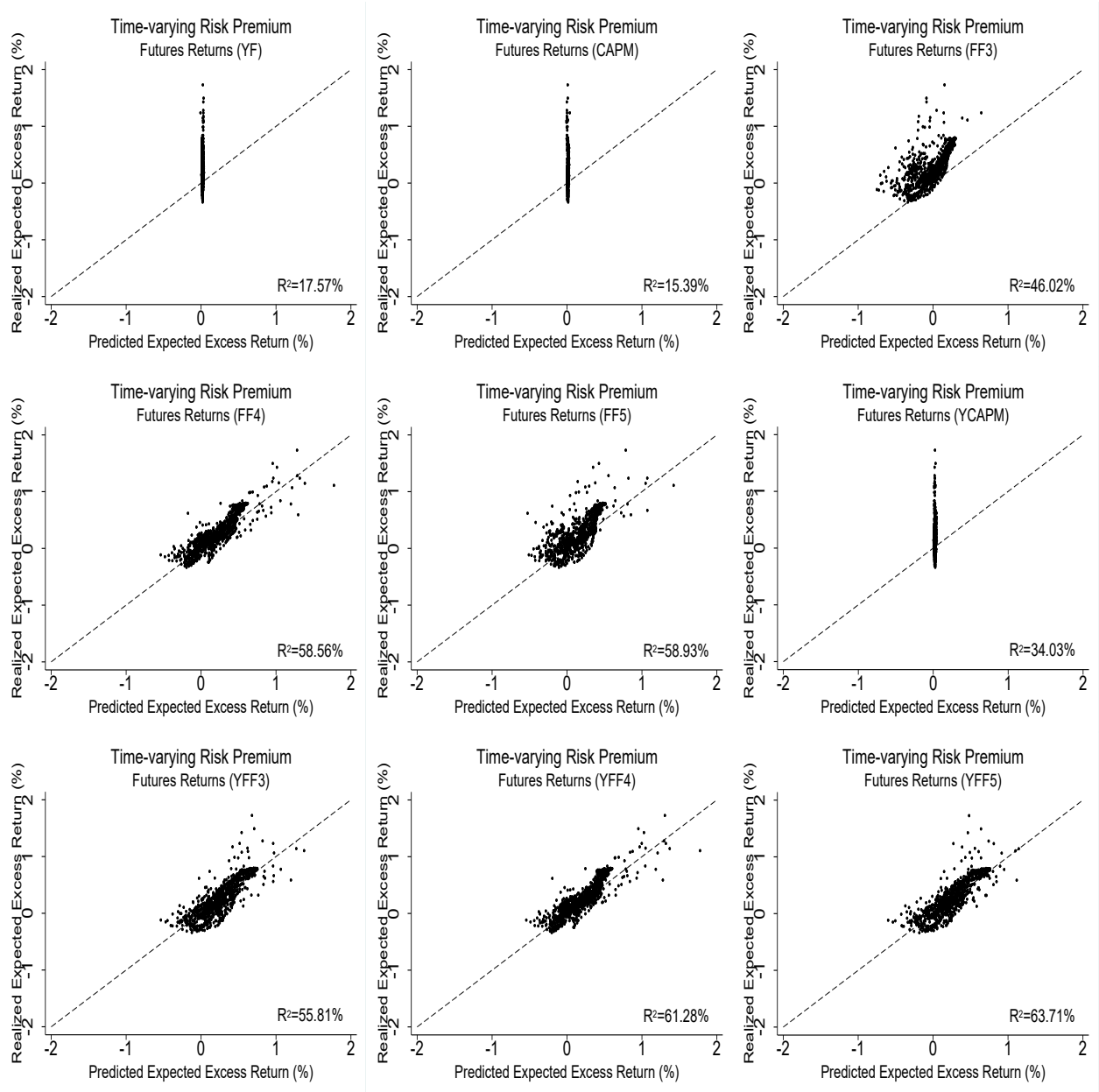


Fig. C.8. Realized and Predicted average returns with time-varying risk premiums for 900 futures momentum strategies. *Note:* The predicted expected returns are calculated with $E\left(WML_{J-K}\right)=\widehat{\beta}_{i,f}^{'}\widehat{\lambda}_{f}$, where $\widehat{\beta}_{i,f}^{'}$ is the estimated beta with the time-series regressions (the first step) of Fama and MacBeth (1973). $\widehat{\lambda}_{f}$ is the estimated risk premia of risk factors with the cross-sectional regressions (the second step) of Fama and MacBeth (1973). The realized expected returns are the average return in the sample from November 1970 to September 2020. The R^2 is the average value of the R_t^2 of the T cross-sectional regressions. That is $R^2=\sum_{t=1}^{T}R_t^2\big/T$. J is the formation period to rank commodities. K is the holding period for the winners and losers portfolios. One period refers to two months. *YF* refers to the model only including HML_y factor. *CAPM* refers to the model only including *MKT* factor. *FF3* refers to the model including *MKT* , *SMB* and *HML* factors. *FF4* refers to the model including *MKT* , *SMB* , *HML* and *MOM* factors. *FF5* refers to the model including *MKT* , *SMB* , *HML* , *RMW* and *CMA* factors. *YCAPM, YFF3, YFF4* and *YFF5* respectively refer to the models including HML_y factor in addition to the factors in *CAPM, FF3, FF4* and *YFF5.*