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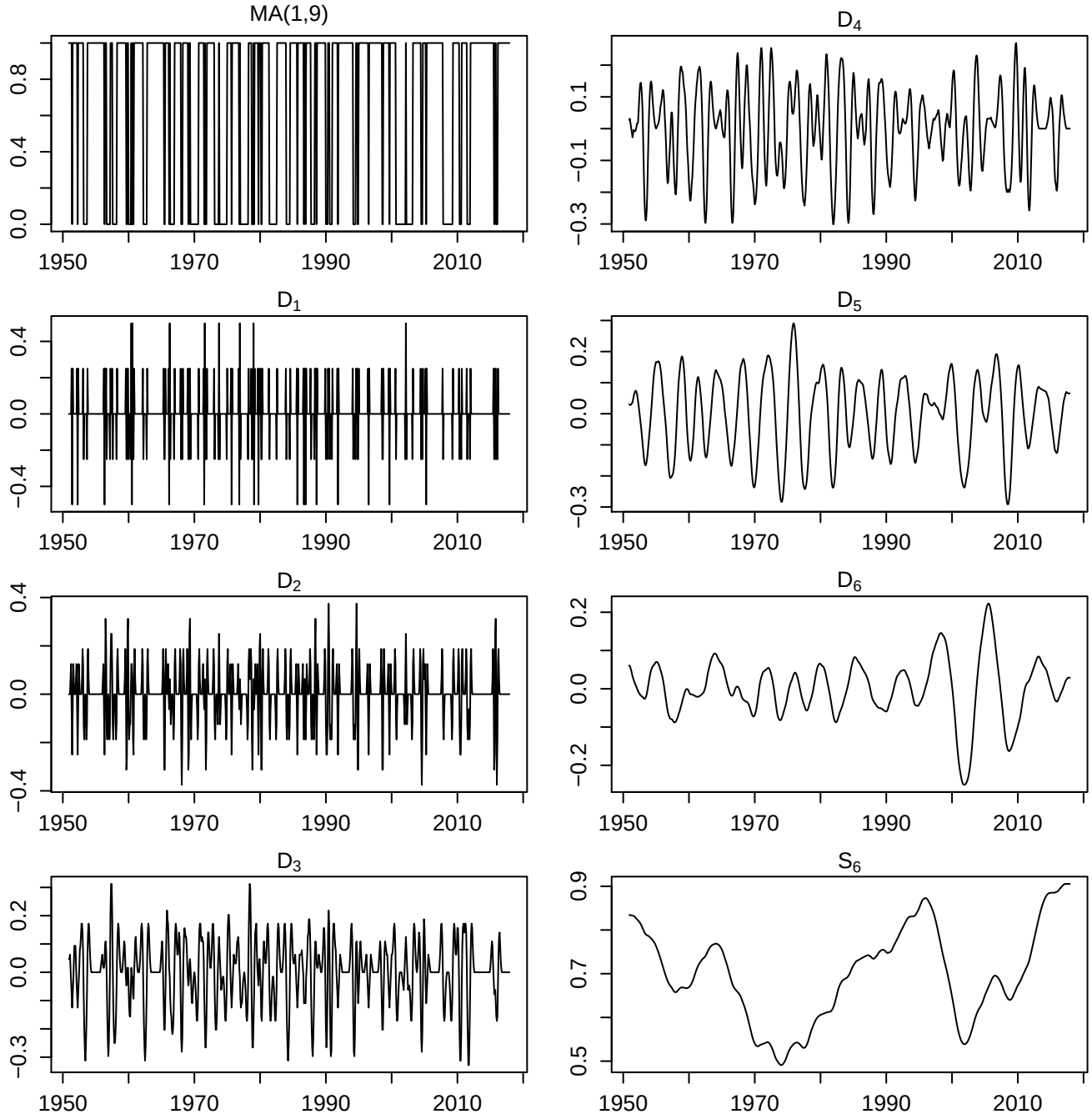

Figure 1

Multiresolution analysis of MA(1,9)

This figure presents the different timescale components for MA(1,9). The time series is decomposed with a MODWT MRA of level $J = 6$ using the Haar filter and data at the boundary are reflected. D_j refers to the level j wavelet detail and S_6 is the wavelet smooth. The sample is 1950:12 to 2017:12.

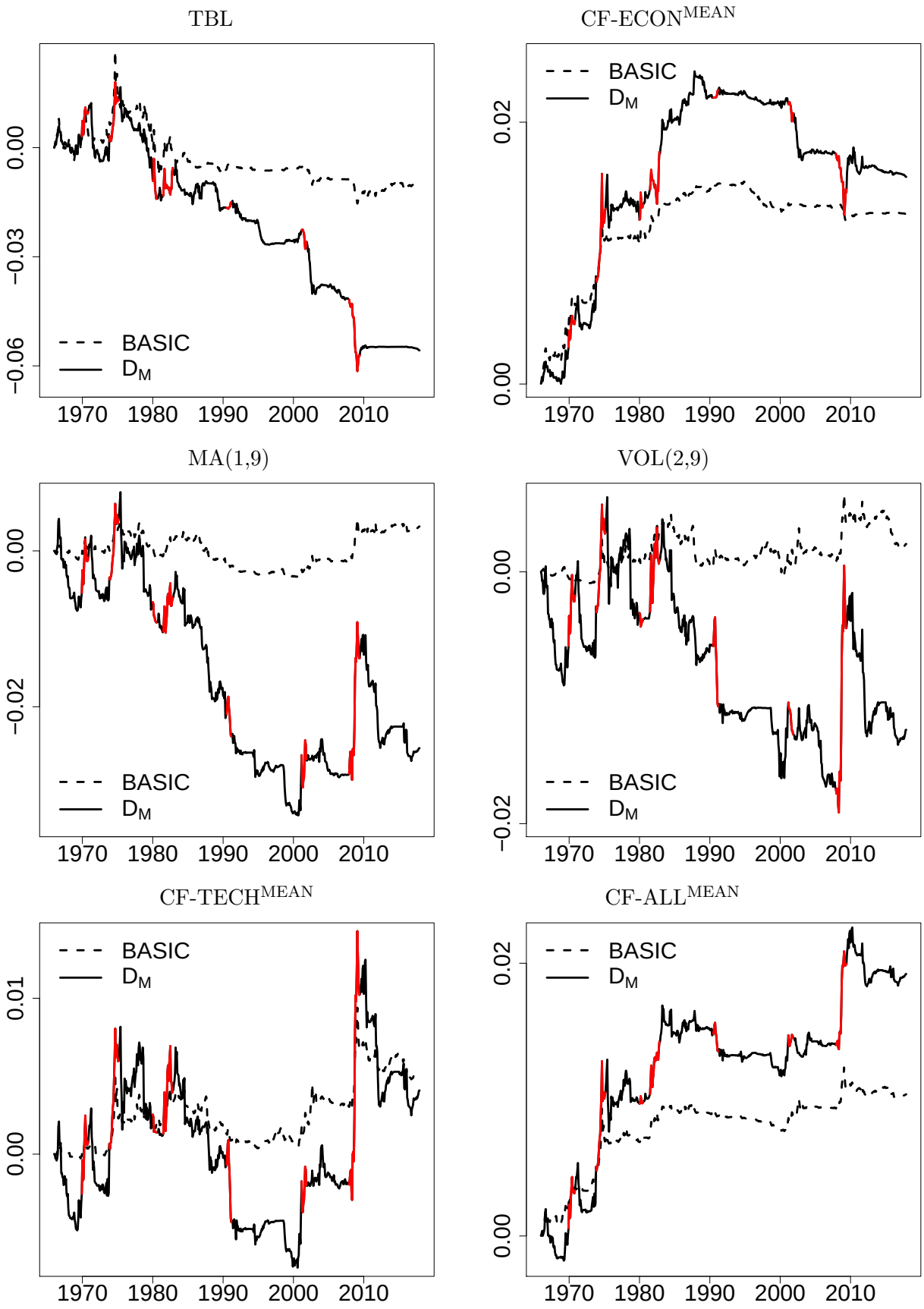

Figure 2

Out-of-sample performance for selected predictors

This figure plots the out-of-sample performance of different forecasting models relative to the historical mean. The dashed black line shows performance of the model with unadjusted predictors, whereas the solid black line presents results for the medium-frequency components. The out-of-sample period runs from 1966:1 to 2017:12 and NBER recession periods are colorized in red for the medium-frequency models.

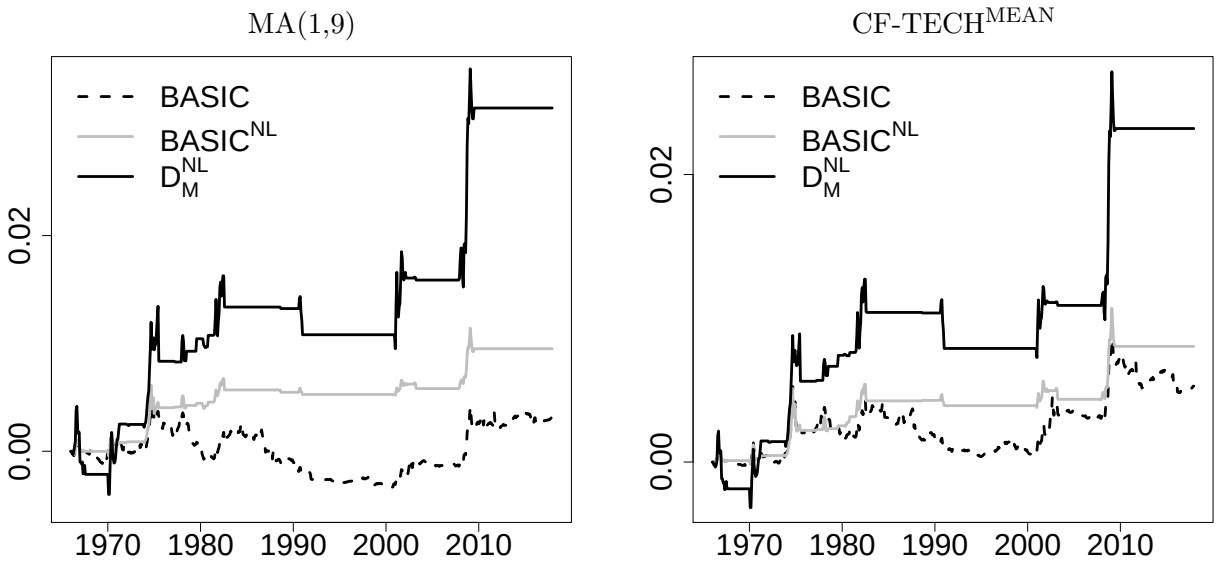

Figure 3

Out-of-sample performance of the nonlinear model

This figure plots the out-of-sample performance of different forecasting models relative to the historical mean. The solid black line shows performance of the nonlinear forecasting model with medium-frequency components, the solid gray line shows performance of the nonlinear forecasting model with unadjusted series, and the dashed black line shows performance of the linear forecasting model with unadjusted series. The relative performance is shown for MA(1,9) and CF-TECH$^{\text{MEAN}}$. The out-of-sample period runs from 1966:1 to 2017:12.

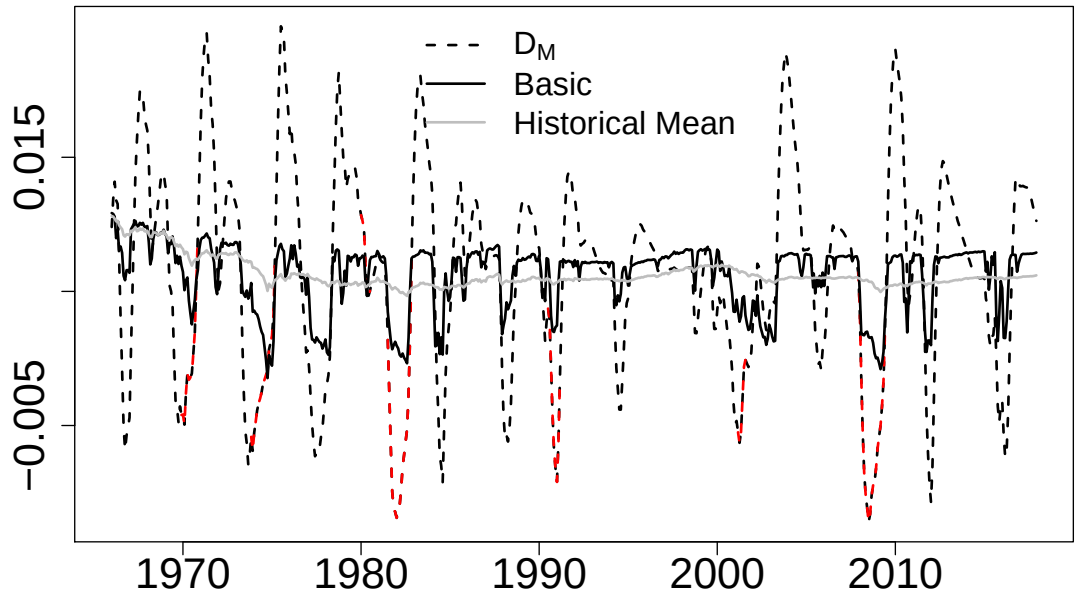

Figure 4

Excess return forecasts from CF-TECH$^{\mathbf{MEAN}}$ and from the historical mean

This figure presents out-of-sample forecasts of excess stock returns from the historical mean (solid gray line), from the combination of forecasts from unadjusted technical indicators (solid black line), and from the combination of forecasts from medium-frequency components of technical indicators (dashed back line). The out-of-sample period runs from 1966:1 to 2017:12.

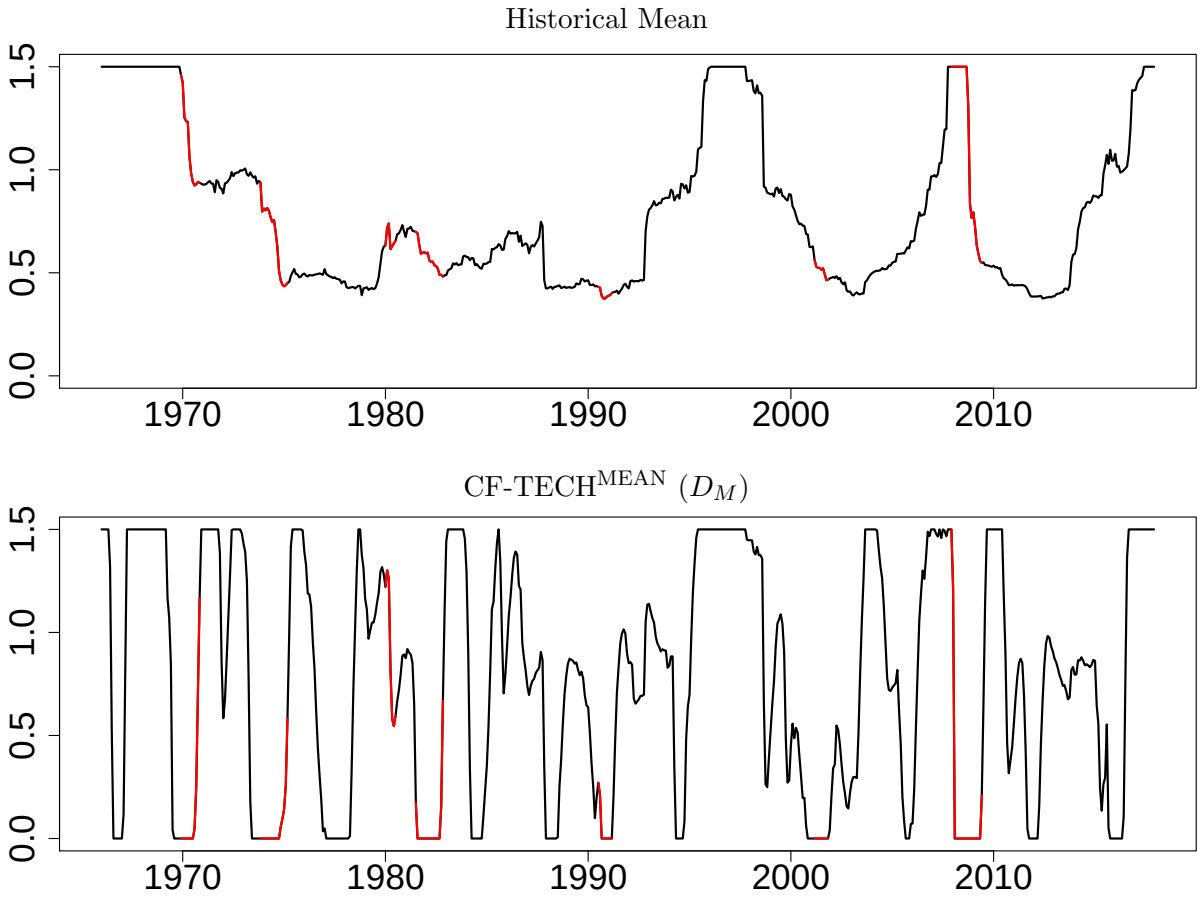

Figure 5

Optimal share in risky assets over time

This figure presents the optimal portfolio weights in risky assets (ω_t^*) for different forecasting models over time. Results are shown for the historical mean (top graph), as well as for the combination of medium-frequency components from technical indicators (bottom graph). The optimal weight of risky assets is restricted to lie between 0 and 1.5. The out-of-sample periods runs from 1966:1 to 2017:12. NBER recession periods are colorized in red.

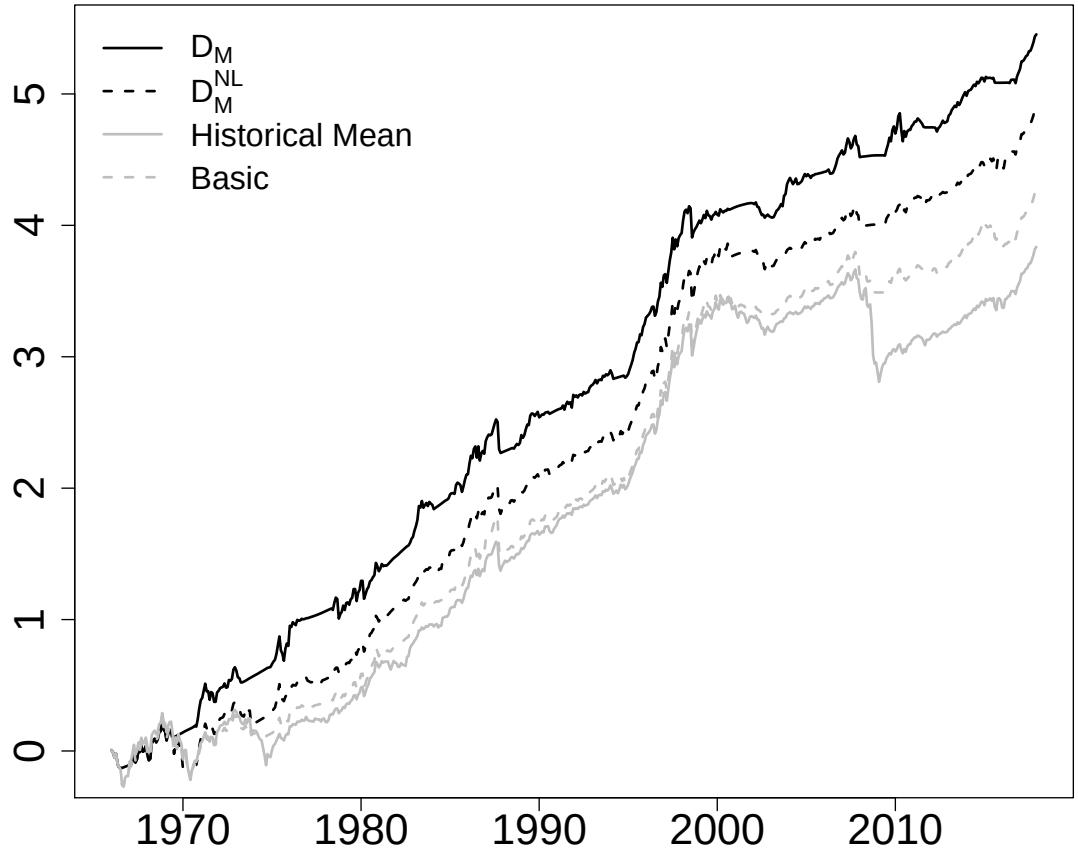

Figure 6

Log cumulative wealth for CF-TECH$^{\mathbf{MEAN}}$ after taking transaction costs into account

This figure presents the log cumulative wealth of four different forecasting models after accounting for transaction costs of 50 basis points per transaction. The sample covers the period from 1966:1 to 2017:12. The solid gray line shows results for the historical mean forecasting model. The dashed gray line (Basic) depicts the log wealth development for CF-TECH$^{\text{MEAN}}$ with a simple average of forecasts from 14 technical indicators. The dashed black line (D_M^{NL}) shows results for the nonlinear forecasting model that combines both combination forecasts from medium range frequencies and the historical mean. D_M depicts combination forecasts from the medium range frequencies of the 14 technical indicators.

Table 1
Summary statistics

This table reports summary statistics of the monthly log equity premium, the 14 economic variables, and the 14 technical indicators. The statistics include the mean (Mean), standard deviation (Std. dev.), skewness (Skew.), kurtosis (Kurt.), minimum (Min.), maximum (Max.), and the first-order autocorrelation (ρ_1). The sample period is 1950:12 to 2017:12.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
			1950:12 to 2017:12				
Variable	Mean	Std. dev.	Skew.	Kurt.	Min.	Max.	ρ_1
Log excess return							
r_t	0.53	4.15	-0.67	5.47	-24.84	14.87	0.06
Economic variables							
DP	-3.53	0.41	-0.21	2.37	-4.52	-2.60	0.99
DY	-3.52	0.42	-0.21	2.40	-4.53	-2.59	0.99
EP	-2.80	0.42	-0.74	5.88	-4.84	-1.90	0.99
DE	-0.73	0.29	2.60	18.78	-1.24	1.38	0.99
RVOL	0.14	0.05	0.83	3.89	0.05	0.32	0.96
BM	0.52	0.25	0.59	2.64	0.12	1.21	0.99
NTIS	0.01	0.02	-0.92	3.72	-0.06	0.05	0.98
TBL	4.28	3.09	0.88	4.08	0.01	16.30	0.99
LTY	5.99	2.76	0.82	3.19	1.75	14.82	0.99
LTR	0.53	2.75	0.51	6.26	-11.24	15.23	0.05
TMS	1.71	1.39	-0.14	2.89	-3.65	4.55	0.96
DFY	0.96	0.44	1.82	7.65	0.32	3.38	0.97
DFR	0.03	1.39	-0.39	9.91	-9.75	7.37	-0.08
INFL	0.29	0.36	0.14	5.71	-1.92	1.81	0.55
Technical indicators							
MA(1,9)	0.70	0.46	-0.86	1.74	0.00	1.00	0.69
MA(1,12)	0.72	0.45	-0.99	1.99	0.00	1.00	0.78
MA(2,9)	0.70	0.46	-0.88	1.77	0.00	1.00	0.76
MA(2,12)	0.72	0.45	-0.98	1.96	0.00	1.00	0.82
MA(3,9)	0.71	0.46	-0.90	1.81	0.00	1.00	0.79
MA(3,12)	0.72	0.45	-0.99	1.97	0.00	1.00	0.82
MOM(9)	0.72	0.45	-0.96	1.92	0.00	1.00	0.76
MOM(12)	0.73	0.44	-1.06	2.12	0.00	1.00	0.80
VOL(1,9)	0.69	0.46	-0.80	1.64	0.00	1.00	0.56
VOL(1,12)	0.71	0.45	-0.94	1.88	0.00	1.00	0.66
VOL(2,9)	0.68	0.47	-0.77	1.59	0.00	1.00	0.73
VOL(2,12)	0.70	0.46	-0.89	1.80	0.00	1.00	0.79
VOL(3,9)	0.69	0.46	-0.84	1.71	0.00	1.00	0.75
VOL(3,12)	0.70	0.46	-0.89	1.80	0.00	1.00	0.82

Table 2

Out-of-sample R^2 statistics (in %) for aggregated timescales

This table presents statistics on the out-of-sample predictability of one month ahead log excess returns on the S&P 500 index. Panel A (Panel B) shows results for economic variables (technical indicators). In addition to the individual forecasts, I display results for three different combination forecasting methods. Panel C shows results when combining both sets of predictors. For each model the out-of-sample R^2 (in %) is displayed (Campbell and Thompson, 2008). *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively according to the Clark and West (2007) MSFE-adjusted statistic. The null hypothesis is equal MSFE and the alternative is that the more sophisticated model has smaller MSFE than the historical mean benchmark. Column (1) shows the respective predictor and column (2) shows results for the unadjusted predictors. Columns (3) to (5) present results for the frequency-decomposed predictors. D_H refers to components with periodicities between 2 to 16 months, D_M refers to components with periodicities between 16 to 64 months, and D_L captures oscillations above 64 months.

(1)	(2)	(3)	(4)	(5)
		1966:1 to 2017:12		
Predictor	Basic	D_H	D_M	D_L
		Panel A: Economic variables		
DP	-0.28	-40.91	-0.24	0.32*
DY	-0.24	-25.39	-0.83	0.32*
EP	-0.60	-42.64	-0.69	-0.30
DE	-0.86	-10.49	-2.13	-0.86
RVOL	-0.07*	-2.89	-1.76	-0.47
BM	-1.25	-27.11	-0.10	-0.71
NTIS	-0.88	0.28*	-3.09	-0.72
TBL	-0.81**	0.63**	-4.75**	-0.64
LTY	-0.71**	1.50***	-2.16***	-0.69
LTR	0.32**	-0.41	-0.77**	0.09
TMS	-0.86**	-0.82	-6.64	-0.54
DFY	-0.63	-8.72	-3.71*	-1.33
DFR	-0.48	-0.68	-3.83**	-2.04
INFL	-0.36	0.28	-0.70*	-0.22
CF-ECON$^{\text{MEAN}}$	1.11***	-2.06	1.35***	0.11
CF-ECON$^{\text{WEIG}}_{\theta=1}$	1.11***	-1.00	1.31***	0.12
CF-ECON$^{\text{WEIG}}_{\theta=0.9}$	1.13***	-0.92	1.25***	0.12
		Panel B: Technical indicators		
MA(1,9)	0.27	-3.47	-2.16**	-7.41
MA(1,12)	0.63*	-2.86	-0.06**	-8.07
MA(2,9)	0.29	-3.35	-0.97**	-6.46
MA(2,12)	0.69**	-2.27	0.45***	-7.44
MA(3,9)	0.39*	-1.78	-0.57**	-5.92
MA(3,12)	0.02	-2.07	0.49**	-7.17
MOM(9)	0.10	-2.71	0.66**	-6.67
MOM(12)	0.12	-2.11	0.82**	-6.16
VOL(1,9)	0.15	-1.53	-2.46**	-2.82
VOL(1,12)	0.46*	-2.10	-0.20***	-3.19
VOL(2,9)	0.19	-2.31	-1.07**	-4.18
VOL(2,12)	0.24	-3.63	-0.04***	-2.52
VOL(3,9)	0.00	-2.24	-0.99**	-2.71
VOL(3,12)	0.64**	-1.98	0.26**	-3.30
CF-TECH$^{\text{MEAN}}$	0.45*	-1.65	0.35***	-4.71
CF-TECH$^{\text{WEIG}}_{\theta=1}$	0.45*	-1.64	0.33**	-4.66
CF-TECH$^{\text{WEIG}}_{\theta=0.9}$	0.46*	-1.65	0.31**	-4.66
		Panel C: All predictors taken together		
CF-ALL$^{\text{MEAN}}$	0.89***	-1.53	1.64***	-1.37
CF-ALL$^{\text{WEIG}}_{\theta=1}$	0.89**	-1.09	1.59***	-1.38
CF-ALL$^{\text{WEIG}}_{\theta=0.9}$	0.90**	-1.05	1.55***	-1.32

Table 3

Testing dependence between current predictability and business-cycle expectations

This table reports p-values for the null hypothesis that current predictability is independent of business-cycle expectations. Current predictability in Panel A is defined as $cp_t = \mathbf{I}[(r_t - \hat{r}_t)^2 - (r_t - \bar{r}_t)^2 < 0]$, whereas current predictability in Panel B is defined as $cp_t^{\text{HIGH}} = \mathbf{I}[(r_t - \hat{r}_t)^2 - (r_t - \bar{r}_t)^2 < -\text{IQR} \times 1.5]$. IQR is the interquartile range. Business-cycle expectations are estimated from the Liu and Moench (2016) probit model with an optimal threshold according to the maximum Youden index. The p-values are estimated with the dynamically augmented reduced rank regression approach of Pesaran and Timmermann (2009). The out-of-sample period is 1966:1 to 2017:12.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Predictor	Basic	D_H	D_M	D_L	Predictor	Basic	D_H	D_M	D_L
					Panel A: $cp_t = \mathbf{I}[(r_t - \hat{r}_t)^2 - (r_t - \bar{r}_t)^2 < 0]$				
DP	6.53*	1.85**	96.71	9.09*	MA(1,9)	33.97	30.75	82.38	26.39
DY	4.95**	40.10	53.12	8.73*	MA(1,12)	84.36	77.49	38.78	41.38
EP	6.51*	2.87**	84.75	41.17	MA(2,9)	33.84	33.29	17.40	19.31
DE	57.72	79.79	93.20	14.94	MA(2,12)	41.59	42.87	35.40	16.02
RVOL	47.68	61.64	74.08	72.72	MA(3,9)	28.62	41.57	21.83	19.29
BM	0.22***	21.72	26.28	9.78*	MA(3,12)	52.02	44.16	16.94	46.43
NTIS	35.01	25.54	62.29	63.71	MOM(9)	72.66	97.59	77.17	8.24*
TBL	10.66	78.63	95.18	5.15*	MOM(12)	33.43	87.19	4.95**	28.51
LTY	4.18**	50.07	9.22*	5.27*	VOL(1,9)	73.40	36.37	32.04	92.54
LTR	33.99	61.88	44.40	8.93*	VOL(1,12)	14.16	21.25	18.95	89.39
TMS	49.55	39.47	95.84	81.42	VOL(2,9)	52.38	25.19	22.43	97.22
DFY	12.71	79.98	45.75	9.22*	VOL(2,12)	33.48	28.69	64.24	97.17
DFR	72.86	98.22	36.88	82.45	VOL(3,9)	12.51	16.70	26.81	92.53
INFL	0.86***	8.94*	83.84	6.04*	VOL(3,12)	7.93*	67.74	23.20	94.06
$\text{CF-ECON}^{\text{MEAN}}$	22.83	31.52	50.93	19.63	$\text{CF-TECH}^{\text{MEAN}}$	13.93	10.05	31.36	75.01
$\text{CF-ECON}^{\text{WEIG}}_{\theta=1}$	48.25	27.45	55.21	20.95	$\text{CF-TECH}^{\text{WEIG}}_{\theta=1}$	14.04	10.05	31.74	74.85
$\text{CF-ECON}^{\text{WEIG}}_{\theta=0.9}$	71.29	26.11	62.71	21.13	$\text{CF-TECH}^{\text{WEIG}}_{\theta=0.9}$	13.81	9.79*	50.36	74.85
$\text{CF-ALL}^{\text{MEAN}}$	53.58	12.39	28.03	32.09					
$\text{CF-ALL}^{\text{WEIG}}_{\theta=1}$	39.16	23.36	14.60	69.76					
$\text{CF-ALL}^{\text{WEIG}}_{\theta=0.9}$	39.86	27.29	15.34	74.10					
					Panel B: $cp_t^{\text{HIGH}} = \mathbf{I}[(r_t - \hat{r}_t)^2 - (r_t - \bar{r}_t)^2 < -\text{IQR} \times 1.5]$				
DP	40.31	97.53	58.01	24.87	MA(1,9)	4.34**	61.50	0.00***	33.78
DY	91.84	40.01	80.97	20.72	MA(1,12)	20.00	26.82	1.31**	35.06
EP	19.28	85.52	18.01	37.29	MA(2,9)	5.53*	12.97	0.02***	32.64
DE	82.65	65.81	82.87	42.69	MA(2,12)	30.40	3.40**	7.08*	50.90
RVOL	2.09**	10.86	18.58	55.48	MA(3,9)	9.06*	20.61	0.25***	45.92
BM	0.11***	83.68	39.90	32.39	MA(3,12)	98.50	42.02	4.55**	52.12
NTIS	20.54	52.18	97.22	59.02	MOM(9)	5.38*	68.23	37.13	69.60
TBL	16.98	14.03	2.20**	93.56	MOM(12)	63.64	87.97	33.80	23.07
LTY	12.21	7.52*	28.53	12.09	VOL(1,9)	67.52	83.95	0.03***	73.28
LTR	15.22	6.52*	73.41	10.87	VOL(1,12)	11.16	10.42	0.00***	66.30
TMS	11.08	54.58	1.38**	1.79**	VOL(2,9)	90.78	31.93	0.19***	48.63
DFY	1.87**	62.70	0.50***	10.42	VOL(2,12)	53.13	86.92	0.02***	66.18
DFR	7.56*	2.07**	21.51	85.55	VOL(3,9)	0.05***	14.46	0.01***	66.50
INFL	1.25**	69.95	83.07	65.84	VOL(3,12)	9.15*	42.46	0.05***	32.16
$\text{CF-ECON}^{\text{MEAN}}$	31.09	38.11	6.95*	98.08	$\text{CF-TECH}^{\text{MEAN}}$	13.25	74.78	0.01***	86.80
$\text{CF-ECON}^{\text{WEIG}}_{\theta=1}$	28.61	54.40	5.46*	88.07	$\text{CF-TECH}^{\text{WEIG}}_{\theta=1}$	13.15	72.26	0.00***	89.74
$\text{CF-ECON}^{\text{WEIG}}_{\theta=0.9}$	47.24	51.38	4.53**	62.66	$\text{CF-TECH}^{\text{WEIG}}_{\theta=0.9}$	13.15	72.26	0.00***	89.74
$\text{CF-ALL}^{\text{MEAN}}$	22.04	61.19	6.46*	88.34					
$\text{CF-ALL}^{\text{WEIG}}_{\theta=1}$	31.65	51.16	10.01	72.55					
$\text{CF-ALL}^{\text{WEIG}}_{\theta=0.9}$	24.34	51.16	9.96*	73.95					

Table 4

Out-of-sample R^2 statistics (in %) for the nonlinear model

This table presents statistics on the out-of-sample predictability of one month ahead log excess returns on the S&P 500 index. Panel A (Panel B) shows results for economic variables (technical indicators). In addition to the individual forecasts, I display results for three different combination forecasting methods. Panel C shows results when combining both sets of predictors. For each model the out-of-sample R^2 (in %) is displayed (Campbell and Thompson, 2008). *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively according to the Clark and West (2007) MSFE-adjusted statistic. The null hypothesis is equal MSFE and the alternative is that the more sophisticated model has smaller MSFE than the historical mean benchmark. Column (1) shows the respective predictor and column (2) shows results for the unadjusted series. Columns (3) to (9) present results for the frequency-decomposed predictors. D_H refers to components with periodicities between 2 to 16 months, D_M refers to components with periodicities between 16 to 64 months, and D_L captures oscillations above 64 months. The superscript NL indicates that the nonlinear forecasting model is applied in columns (3), (5), (7), and (9).

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
				1966:1 to 2017:12				
Predictor	Basic	Basic$^{\text{NL}}$	D_H	D_H^{NL}	D_M	D_M^{NL}	D_L	D_L^{NL}
				Panel A: Economic variables				
DP	-0.28	0.56*	-40.91	-24.64	-0.24	-0.17	0.32*	0.49***
DY	-0.24	0.80**	-25.39	-13.39	-0.83	-0.30	0.32*	0.53***
EP	-0.60	-0.41	-42.64	-22.67	-0.69	-0.06	-0.30	-0.07
DE	-0.86	-0.42	-10.49	-6.05	-2.13	-0.08	-0.86	-0.42
RVOL	-0.07*	0.40*	-2.89	-1.38	-1.76	-0.43	-0.47	-0.19
BM	-1.25	-0.46	-27.11	-15.53	-0.10	-0.03	-0.71	-0.54
NTIS	-0.88	-1.27	0.28*	0.04	-3.09	-2.76	-0.72	-0.12
TBL	-0.81**	-1.62	0.63**	-0.61	-4.75**	-1.57	-0.64	-1.27
LTY	-0.71**	-1.56	1.50	0.29*	-2.16***	-1.91	-0.69	-1.10
LTR	0.32**	1.00**	-0.41	0.75**	-0.77**	-0.38	0.09	0.22
TMS	-0.86**	0.19**	-0.82	-0.76	-6.64	-1.66	-0.54	-0.09
DFY	-0.63	0.07	-8.72	-6.53	-3.71*	-0.74*	-1.33	-0.95
DFR	-0.48	-0.14	-0.68	-0.16	-3.83**	0.72*	-2.04	-1.16
INFL	-0.36	-1.11	0.28	0.65**	-0.70*	-0.87	-0.22	-1.22
CF-ECON$^{\text{MEAN}}$	1.11***	0.37*	-2.06	-2.19	1.35***	0.46	0.11	-0.13
CF-ECON$^{\text{WEIG}}_{\theta=1}$	1.11***	0.43*	-1.00	-1.35	1.31***	0.60*	0.12	-0.13
CF-ECON$^{\text{WEIG}}_{\theta=0.9}$	1.13***	0.48*	-0.92	-1.33	1.25***	0.62*	0.12	-0.11
				Panel B: Technical indicators				
MA(1,9)	0.27	0.81**	-3.47	-1.89	-2.16**	2.71***	-7.41	-3.23
MA(1,12)	0.63*	0.86**	-2.86	-1.50	-0.06**	1.93***	-8.07	-3.46
MA(2,9)	0.29	0.95**	-3.35	-2.05	-0.97**	2.45***	-6.46	-2.68
MA(2,12)	0.69**	0.97**	-2.27	-1.31	0.45***	1.84***	-7.44	-3.08
MA(3,9)	0.39*	1.03**	-1.78	-1.21	-0.57**	2.17***	-5.92	-2.85
MA(3,12)	0.02	0.44*	-2.07	-1.71	0.49**	1.47***	-7.17	-3.20
MOM(9)	0.10	0.30	-2.71	-1.65	0.66**	1.44**	-6.67	-3.02
MOM(12)	0.12	0.20	-2.11	-0.85	0.82**	1.01**	-6.16	-2.59
VOL(1,9)	0.15	0.63**	-1.53	-0.96	-2.46**	1.70***	-2.82	-1.12
VOL(1,12)	0.46*	0.78**	-2.10	-1.35	-0.20***	1.79***	-3.19	-1.54
VOL(2,9)	0.19	0.46*	-2.31	-1.33	-1.07**	1.75***	-4.18	-2.12
VOL(2,12)	0.24	0.28	-3.63	-2.15	-0.04***	1.56***	-2.52	-1.21
VOL(3,9)	0.00	0.48*	-2.24	-1.53	-0.99**	1.75***	-2.71	-1.20
VOL(3,12)	0.64**	0.85**	-1.98	-1.39	0.26**	1.44***	-3.30	-1.62
CF-TECH$^{\text{MEAN}}$	0.45*	0.69**	-1.65	-1.32	0.35***	1.98***	-4.71	-2.24
CF-TECH$^{\text{WEIG}}_{\theta=1}$	0.45*	0.69**	-1.64	-1.32	0.33**	1.97***	-4.66	-2.23
CF-TECH$^{\text{WEIG}}_{\theta=0.9}$	0.46*	0.69**	-1.65	-1.32	0.31**	1.97***	-4.66	-2.22
				Panel C: All predictors taken together				
CF-ALL$^{\text{MEAN}}$	0.89***	0.56**	-1.53	-1.61	1.64***	1.52***	-1.37	-0.82
CF-ALL$^{\text{WEIG}}_{\theta=1}$	0.89**	0.60**	-1.09	-1.24	1.59***	1.59***	-1.38	-0.84
CF-ALL$^{\text{WEIG}}_{\theta=0.9}$	0.90**	0.63**	-1.05	-1.23	1.55***	1.61***	-1.32	-0.77

Table 5
Annualized gains in CER

This table reports the annualized gain in certainty equity return (CER) relative to the CER from the historical mean (in percent). ΔCER is estimated for a mean-variance investor with a relative risk aversion of five who allocates each month between the S&P 500 index and the risk-free rate. The optimal weight is estimated according to forecasts of one-month ahead excess returns from predictive regression models. The optimal weight in risky assets is constrained to lie between 0 and 1.5 to prevent shorting stocks and leveraging more than 50%. The out-of-sample period runs from 1966:1 to 2017:12.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
				1966:1 to 2017:12				
Predictor	Basic	Basic$^{\text{NL}}$	D_H	D_H^{NL}	D_M	D_M^{NL}	D_L	D_L^{NL}
				Panel A: Economic variables				
DP	-0.67	0.53	-3.05	-3.18	0.19	0.13	0.65	0.94**
DY	-0.24	1.08	-3.93	-2.50	-1.34	-0.56	0.70	1.06**
EP	0.25	0.44	-0.83	-0.49	0.28	0.83*	-0.24	0.08
DE	-0.32	0.18	-0.12	-0.52	-1.01	0.18	0.25	0.56
RVOL	-1.04	0.00	-0.45	-0.64	-1.45	-0.58	-0.24	0.02
BM	-1.25	-0.13	-3.46	-3.06	0.15	0.15	-0.60	-0.26
NTIS	0.14	-0.89	0.76	0.12	0.00	-1.55	-0.51	0.58
TBL	1.80*	-0.01	1.16*	-0.33	1.11	0.70	1.52	-0.00
LTY	1.65	-0.01	3.13***	1.05*	2.39*	0.04	1.15	-0.11
LTR	0.87	0.83*	0.20	0.63	1.48	0.80	0.52	0.37
TMS	1.79	0.93	-1.24	-0.92	-0.61	0.66	1.10	0.58
DFY	-0.78	-0.21	-0.31	-0.44	-1.03	0.35	0.18	0.01
DFR	0.16	0.17	-0.65	-0.38	1.03	1.23	0.81	1.21
INFL	0.27	-0.53	0.74	1.19	1.79	0.90	1.67	0.08
CF-ECON$^{\text{MEAN}}$	1.72***	0.67*	-1.47	-2.01	2.32**	0.69	0.99	0.59
CF-ECON$^{\text{WEIG}}_{\theta=1}$	1.82***	0.83*	-0.88	-1.46	2.39**	0.90*	1.03	0.63
CF-ECON$^{\text{WEIG}}_{\theta=0.9}$	1.83***	0.89*	-0.86	-1.48	2.39**	0.94*	1.05	0.66
				Panel B: Technical indicators				
MA(1,9)	1.55*	1.96***	-1.92	-1.00	2.92*	3.53***	-0.05	1.17
MA(1,12)	2.62**	2.57***	-1.64	-0.89	3.56**	2.97***	-0.18	1.11
MA(2,9)	1.75*	2.41***	-1.76	-1.13	2.99**	3.36***	0.36	1.28
MA(2,12)	2.67**	2.71***	-1.45	-0.85	3.58***	2.89***	-0.07	1.11
MA(3,9)	2.18*	2.58***	-1.45	-0.88	2.77**	2.94***	0.05	0.95
MA(3,12)	1.15	1.50**	-0.55	-0.78	2.85**	2.31**	-0.25	0.98
MOM(9)	1.23	1.31*	-0.86	-0.80	3.14**	2.32**	-0.32	0.96
MOM(12)	1.14	1.22*	-0.79	-0.46	2.00*	2.03**	-0.25	1.20
VOL(1,9)	1.18	1.65**	-0.62	-0.60	3.32**	3.15***	0.96	1.68*
VOL(1,12)	1.79*	2.27***	-0.98	-0.70	4.46***	3.16***	0.81	1.65*
VOL(2,9)	0.88	1.44**	-1.21	-0.77	3.66**	2.86***	0.31	1.34
VOL(2,12)	0.89	1.17*	-1.39	-0.92	3.74***	2.67**	0.74	1.57*
VOL(3,9)	0.61	1.27**	-1.07	-0.73	3.26**	2.87***	0.61	1.46
VOL(3,12)	1.88*	2.27***	-0.94	-0.77	3.34**	2.49**	0.51	1.36
CF-TECH$^{\text{MEAN}}$	1.59*	1.85**	-1.02	-0.89	3.71***	3.05***	0.39	1.21
CF-TECH$^{\text{WEIG}}_{\theta=1}$	1.60*	1.86**	-1.00	-0.89	3.71***	3.06***	0.41	1.23
CF-TECH$^{\text{WEIG}}_{\theta=0.9}$	1.60*	1.86**	-1.01	-0.89	3.71***	3.06***	0.41	1.23
				Panel C: All predictors taken together				
CF-ALL$^{\text{MEAN}}$	1.71***	1.24**	-1.90	-2.12	4.31***	2.92***	0.71	1.19
CF-ALL$^{\text{WEIG}}_{\theta=1}$	1.80***	1.35**	-1.39	-1.60	4.17***	2.95***	0.74	1.23
CF-ALL$^{\text{WEIG}}_{\theta=0.9}$	1.82***	1.40**	-1.37	-1.57	4.15***	2.96***	0.76	1.27

Table 6
Annualized gains in SR

This table reports the annualized gain in the Sharpe ratio (SR) relative to the SR from the historical mean. ΔSR is estimated for a mean-variance investor with a relative risk aversion of five who allocates each month between the S&P 500 index and the risk-free rate. The optimal weight is estimated according to forecasts of one-month ahead excess returns from predictive regression models. The optimal weight in risky assets is constrained to lie between 0 and 1.5 to prevent shorting stocks and leveraging more than 50%. The out-of-sample period runs from 1966:1 to 2017:12.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
				1966:1 to 2017:12				
Predictor	Basic	Basic$^{\text{NL}}$	D_H	D_H^{NL}	D_M	D_M^{NL}	D_L	D_L^{NL}
				Panel A: Economic variables				
DP	-0.11	0.06	-0.08	-0.13	-0.01	0.01	0.03	0.06**
DY	-0.08	0.09*	-0.17	-0.09	-0.10	0.00	0.03	0.07**
EP	-0.01	0.03	0.03	-0.01	0.03	0.05	-0.03	-0.00
DE	-0.06	0.01	0.04	0.01	0.00	0.04	-0.02	0.02
RVOL	0.01	0.05	0.02	0.01	-0.01	0.02	-0.03	-0.01
BM	-0.08	0.00	-0.14	-0.15	0.01	0.02	-0.02	-0.03
NTIS	0.06	-0.06	0.06	0.01	0.05	-0.07	-0.04	0.02
TBL	0.12	-0.02	0.10**	-0.00	0.14	0.08	0.09	-0.03
LTY	0.10	-0.03	0.25***	0.09*	0.19**	-0.01	0.04	-0.04
LTR	0.11*	0.08**	0.04	0.06*	0.15**	0.08*	0.05	0.02
TMS	0.19**	0.08*	-0.09	-0.06	0.02	0.08	0.10	0.02
DFY	-0.02	0.01	0.04	0.01	0.01	0.08*	-0.03	-0.03
DFR	0.01	0.01	-0.04	-0.02	0.11	0.10	0.05	0.07
INFL	0.01	-0.05	0.05	0.09**	0.14*	0.07	0.13*	-0.02
CF-ECON$^{\text{MEAN}}$	0.11**	0.04	-0.05	-0.08	0.19***	0.07*	0.05	0.01
CF-ECON$^{\text{WEIG}}_{\theta=1}$	0.12**	0.05*	-0.03	-0.06	0.19***	0.08*	0.05	0.02
CF-ECON$^{\text{WEIG}}_{\theta=0.9}$	0.12**	0.06*	-0.03	-0.06	0.19***	0.08**	0.05	0.02
				Panel B: Technical indicators				
MA(1,9)	0.10*	0.13***	-0.10	-0.08	0.24**	0.27***	0.03	0.06
MA(1,12)	0.19**	0.18**	-0.09	-0.07	0.28**	0.22***	0.04	0.06
MA(2,9)	0.12*	0.17***	-0.10	-0.09	0.24**	0.26***	0.07	0.07
MA(2,12)	0.20**	0.20***	-0.09	-0.06	0.28***	0.21***	0.04	0.06
MA(3,9)	0.16*	0.19***	-0.09	-0.07	0.22**	0.22***	0.05	0.05
MA(3,12)	0.07	0.09*	-0.02	-0.06	0.22**	0.16**	0.03	0.05
MOM(9)	0.07	0.08	-0.04	-0.06	0.24**	0.16**	0.03	0.05
MOM(12)	0.07	0.07	-0.04	-0.03	0.14*	0.14**	0.04	0.07
VOL(1,9)	0.07	0.11**	-0.01	-0.05	0.26**	0.24***	0.09	0.11
VOL(1,12)	0.13*	0.16***	-0.05	-0.06	0.35***	0.24***	0.08	0.11
VOL(2,9)	0.06	0.09**	-0.06	-0.06	0.29***	0.21***	0.05	0.08
VOL(2,12)	0.06	0.07	-0.08	-0.07	0.30***	0.20**	0.08	0.10
VOL(3,9)	0.04	0.08**	-0.05	-0.05	0.26**	0.21***	0.07	0.09
VOL(3,12)	0.14*	0.16***	-0.06	-0.06	0.26***	0.18**	0.06	0.08
CF-TECH$^{\text{MEAN}}$	0.11*	0.12**	-0.05	-0.07	0.29***	0.23***	0.07	0.07
CF-TECH$^{\text{WEIG}}_{\theta=1}$	0.11*	0.12**	-0.05	-0.07	0.29***	0.23***	0.07	0.07
CF-TECH$^{\text{WEIG}}_{\theta=0.9}$	0.11*	0.13**	-0.05	-0.07	0.29***	0.23***	0.07	0.07
				Panel C: All predictors taken together				
CF-ALL$^{\text{MEAN}}$	0.11***	0.08**	-0.09	-0.11	0.34***	0.22***	0.06	0.06
CF-ALL$^{\text{WEIG}}_{\theta=1}$	0.12***	0.08**	-0.07	-0.09	0.33***	0.22***	0.07	0.07
CF-ALL$^{\text{WEIG}}_{\theta=0.9}$	0.12***	0.09**	-0.07	-0.09	0.33***	0.22***	0.07	0.07

Online Appendix for
"Out-of-Sample Equity Premium Prediction: Combination Forecasts with Frequency-Decomposed Variables"

Not for Publication

A R^2_{OS} for individual timescales

In the main article I have only provided results for the aggregated timescales D_H, D_M, and D_L. Table A.1 shows the R^2_{OS} statistics for the individual timescales D_1 to D_6, and S_6. Panel B highlights that predictability by technical indicators solely stems from D_4 and D_5, which approximates periodicities between 16 to 32 months and 32 to 64 months.

B Recession forecasts and differences in squared forecasting errors

The so called receiver operating characteristic (ROC) curve plots the entire set of possible combinations of TPR(θ) and FPR(θ) (Berge and Jordà, 2011). Figure A.1 presents the ROC curve for the grid of candidate values for the full sample from 1950:12 to 2017:12. Firstly, I generate in-sample predictions for the probability of a recession one-month ahead. Secondly, I estimate the respective values of TPR(θ) and FPR(θ) for the 101 candidate values. Then, the value is selected that maximizes the difference between both ratios. Graphically, the optimal point is the point with the largest distance to the diagonal line (Baker and Kramer, 2007). The dashed diagonal line is the equivalent of a random guess and a model with optimal accuracy "would have a ROC curve that hugged the top left corner" (Liu and Moench, 2016, p. 1141). The ROC curve shows that the probit model has an excellent classification ability for the full sample. For the in-sample exercise the optimal threshold level equals $\theta^* = 0.19$. The one-month ahead recession forecasts from the probit model are shown in the right panel of Figure A.1.

Figure A.2 shows boxplots of $(r_t - \hat{r}_t)^2 - (r_t - \bar{r}_t)^2$ for the 14 medium-frequency components of the technical indicators (D_M). The difference in squared forecast errors is centered around zero with outliers both to the left (D_M performs better) and the right (historical mean performs better). A predictor that consistently outperforms the naive benchmark would only have observations to the left of zero. I show in the main article

that points on the left side of the distribution depend on business-cycle expectations.

C Asset allocation exercise with alternative choice of parameters

In this section I set the parameters of the asset allocation exercise identical to Rapach et al. (2016). I restrict the share of risky assets to lie between -0.5 and 1.5, allowing for a short position in risky assets of 50%. The coefficient of relative risk aversion is set to three and the volatility forecast is estimated according to a ten-year moving window of past excess returns. The results for ΔCER and ΔSR under this specification are shown in Table A.2 and Table A.3.

D Subsample analysis: 1990:1 to 2017:12

Tables A.4 to A.6 present results for the out-of-sample period from 1990:1 to 2017:12. Results remain qualitatively the same. For the more recent sample the combination forecasts of economic variables perform rather poor. Contrarily, combination forecasts of medium frequencies from technical indicators provide a sizable utility gain of 357 basis points relative to the historical mean, and a gain of 143 basis points relative to combination forecasts from the unadjusted indicators. The R^2_{OS} for the nonlinear forecasting model with combination forecasts from medium frequencies of technical indicators is 2.25%. This is more than three times larger than for the simple combination forecasts.

E Principal component analysis

Similar to Neely et al. (2014), I analyze the forecasting performance of principal components. Firstly, I split each predictor into frequency-specific components and then group the respective components for all predictors. Thus, the frequency-specific information of all predictors is saved in respective matrices. Secondly, I normalize the predictors to have a mean of zero and a standard deviation of one. Thirdly, I estimate the first,

second, and third principal components of the frequency-specific matrices. Table A.7 shows the R^2_{OS} values, whereas Table A.8 and Table A.9 present results for ΔCER and ΔSR.

F Alternative choice of wavelet filter

In the main text I have only applied the Haar wavelet filter to decompose time series. The choice of the Haar filter is often justified by the fact that "the wavelet coefficients are simply differences of moving averages" (Faria and Verona, 2018a). Ortu et al. (2013) show that the Haar filter is a simple method to decompose time series along the persistence dimension. Bandi et al. (2019a, p. 17) write that "alternative nonparametric filters, like the Daubechies filter, could have been used instead without affecting the empirical results". Likewise, Kang et al. (2017, p. 24) use the "least asymmetric" wavelet filter, writing that their findings "are not specific to the particular wavelet filter used". In line with this, Rua (2011, p. 671) states that results do not change much when using Daubechies and Coiflets rather than a symmlet 4 wavelet. Similarly, Risse (2019) explains that Daubechies wavelets do not lead to superior performance compared to the Haar wavelet. So, the choice of wavelet seems to be a "technical note" rather than a crucial choice (Kang et al., 2017, p. 24). Percival and Walden (2000, p. 197) write the following:

> "To summarize, as compared to DWT-based MRAs, a MODWT-based MRA is less dependent upon our choice of wavelet filter, but not so much so that we can recommend always using a particular filter. A careful study of the differences between MRAs based on different wavelet filters is still needed to see which filter is best matched to a particular application."

Hence, there is no clear guidance on the choice of wavelet. Therefore, I simply repeat the analysis from the previous sections with four different wavelets. Table A.10 presents

results for R^2_{OS}, ΔCER, and ΔSR, when using combination forecasts and alternative wavelets to isolate the medium-frequency components of predictors. It can be seen that results are qualitatively the same, with different wavelets only having a minor effect. The wavelets with a lower width (D(4) and FK(4)) seem to perform slightly better in terms of R^2_{OS} compared to wavelets with a width of 8 or 16 observations.[1] However, the overall role of wavelet choice is subordinate. Thus, my findings are in line with other articles documenting that the choice of filter is of minor importance.

G Performance after transaction costs

Table A.11 presents the average turnover of portfolios resulting from advanced forecasting models relative to the average turnover of the portfolio based on forecasts from the historical mean. The average turnover of a portfolio based on the historical mean forecast is 2.13%. None of the portfolios from more advanced forecasting models has a relative average turnover below one. Each of these portfolios has higher transaction costs, therefore it is important to analyze whether the gains in ΔCER and ΔSR remain significant after accounting for these costs. Table A.13 and Table A.14 show results after accounting for a proportional transaction cost of 50 basis points per transaction. As an example, the combination forecasts from medium frequencies of all predictors generate a utility gain of 396 basis points relative to the historical mean, and a utility gain of 250 basis points relative to the unadjusted predictors. The results remain sizable after accounting for transaction costs.

[1] The Haar wavelet has a width of 2 and as well belongs to discrete Daubechies wavelets. Therefore, the Haar wavelet is also called D(2) wavelet.

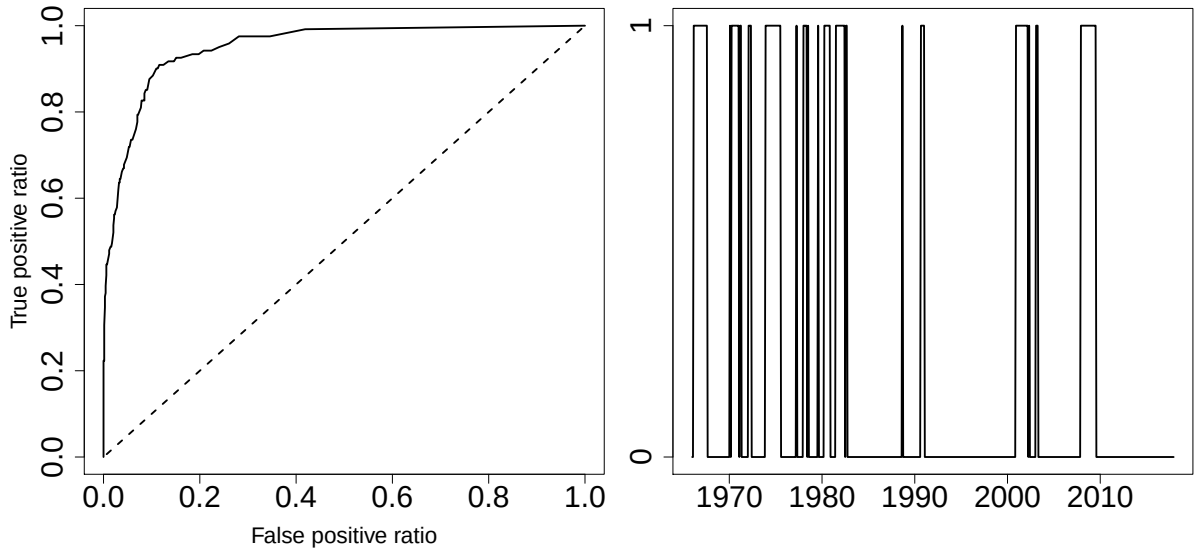

Figure A.1

ROC curve and business-cycle forecasts

This figure plots the ROC curve for the in-sample period from 1950:12 to 2017:12 (left panel) and the out-of-sample recession forecasts for the period from 1966:1 to 2017:12 (right panel). The recession periods are classified according to the maximum Youden index and the probability forecasts are based on the probit model.

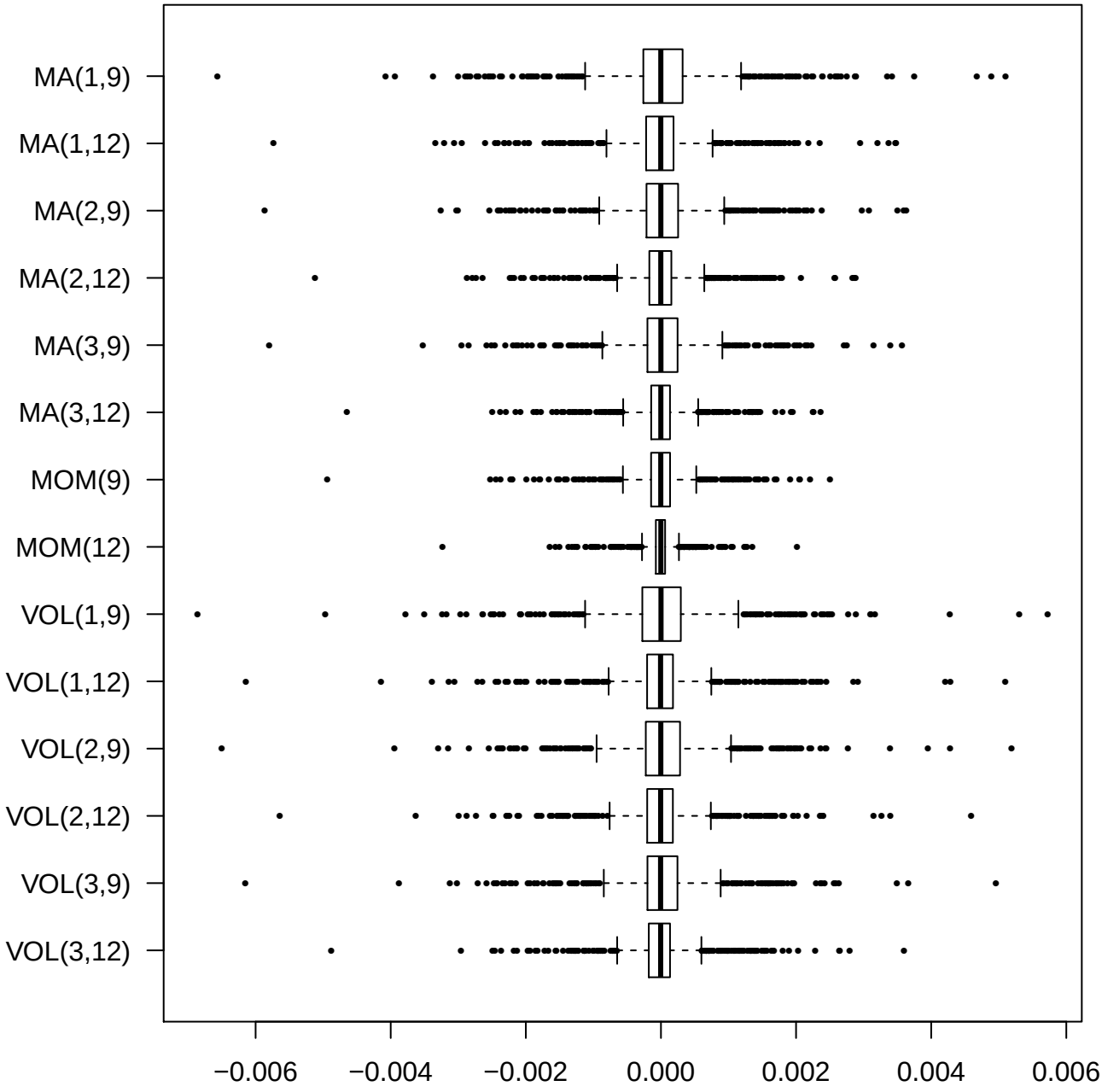

Figure A.2

Boxplots for differences in squared forecasting errors

This figure presents boxplots for differences in squared forecasting errors. The squared errors from forecasts with medium-frequency components of technical indicators are subtracted from squared forecasting errors of the historical mean, $(r_t - \hat{r}_t)^2 - (r_t - \bar{r}_t)^2$. The out-of-sample forecasting period is 1966:1 to 2017:12. The ends of the box are the upper and lower quartiles, so the box spans the interquartile range (IQR). The whiskers are the dashed lines that extend from both sides of the box up to the highest or lowest value within $\pm 1.5 \times$ IQR. The dots represent points that are outside of this range.

Table A.1

Out-of-sample R^2 statistics (in %)

This table presents statistics on the out-of-sample predictability of one month ahead log excess returns on the S&P 500 index. Panel A (Panel B) shows results for economic variables (technical indicators). In addition to the individual forecasts, I display results for three different combination forecasting methods. Panel C shows results when combining both sets of predictors. For each model the out-of-sample R^2 (in %) is displayed (Campbell and Thompson, 2008). *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively according to the Clark and West (2007) MSFE-adjusted statistic. The null hypothesis is equal MSFE and the alternative is that the more sophisticated model has smaller MSFE than the historical mean benchmark. Column (1) shows the respective predictor and column (2) shows results for the unadjusted series. Columns (3) to (9) present results for the frequency-decomposed predictors. D_1 refers to the component with the highest frequency and S_6 refers to the component with the lowest frequency.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
				1966:1 to 2017:12				
Predictor	Basic	D_1	D_2	D_3	D_4	D_5	D_6	S_6
				Panel A: Economic variables				
DP	-0.28	-29.86	-26.21	-4.30	-0.49	-0.20	-0.80	0.18
DY	-0.24	-0.13	-53.15	-20.07	-2.62	-0.19	-0.56	0.16
EP	-0.60	-38.56	-28.80	-0.71	-0.30	-1.09	-1.63	-0.11
DE	-0.86	-6.23	-18.18	-5.27	-2.34	-2.19	-1.24	-0.17
RVOL	-0.07*	-0.47	-4.34	-7.66	-5.23	-0.65	-0.49	-0.31
BM	-1.25	-17.58	-17.07	-3.05	-0.71	0.05	-1.11	-0.55
NTIS	-0.88	-0.44	0.25	-1.66	-3.50	-2.20	-0.62	-0.51
TBL	-0.81**	-1.96	-0.27	-0.94**	-7.82**	-2.77**	-2.10	-0.20
LTY	-0.71**	-0.47	0.76**	-2.23***	-2.37***	-1.56*	-1.09	-0.41
LTR	0.32**	0.38*	-2.22*	-3.45	-1.40**	0.02**	0.04	-1.31
TMS	-0.86**	-1.39	-1.18	-1.34	-8.75	-3.92*	-1.83	-0.18
DFY	-0.63	-1.20	-5.02	-17.45	-8.42*	-1.55	-0.93	-1.13
DFR	-0.48	-0.49	-0.71	-3.54	-3.79*	-2.55	-1.35	-1.41
INFL	-0.36	0.16	0.32*	-1.06	-2.26	0.51**	-0.10	-0.09
CF-ECON$^{\text{MEAN}}$	1.11***	-1.82	-1.91	-0.59	1.05***	0.95**	-0.38	0.08
CF-ECON$^{\text{WEIG}}_{\theta=1}$	1.11***	-1.70	-1.19	-0.49	0.91**	0.99**	-0.35	0.09
CF-ECON$^{\text{WEIG}}_{\theta=0.9}$	1.13***	-1.70	-1.11	-0.47	0.85**	0.98**	-0.33	0.09
				Panel B: Technical indicators				
MA(1,9)	0.27	-2.88	-2.55	-0.15	-2.42*	-1.87**	-9.30	-3.66
MA(1,12)	0.63*	-2.82	-2.64	0.09	-0.15**	-0.54**	-8.39	-4.06
MA(2,9)	0.29	-1.85	-6.89	0.08	-1.10*	-1.08**	-7.80	-3.16
MA(2,12)	0.69**	-0.90	-5.41	-0.25	0.32**	-0.17**	-6.96	-4.34
MA(3,9)	0.39*	-0.43	-4.80	-0.18	-0.60*	-0.89**	-6.57	-2.91
MA(3,12)	0.02	-0.26	-4.61	-1.14	0.42**	-0.30**	-6.77	-3.89
MOM(9)	0.10	-1.21	-1.58	-0.75	0.58**	-0.27**	-6.57	-3.65
MOM(12)	0.12	-0.78	-1.89	-1.43	0.31*	0.36**	-5.05	-3.74
VOL(1,9)	0.15	-1.15	-1.26	-0.56	-2.81*	-1.53**	-3.40	-1.20
VOL(1,12)	0.46*	-0.65	-2.44	0.10	-0.39**	-0.32***	-3.51	-1.36
VOL(2,9)	0.19	-0.52	-5.02	-0.09	-0.92*	-1.16***	-4.82	-1.51
VOL(2,12)	0.24	-1.06	-6.23	-0.60	0.20**	-0.87**	-4.10	-0.93
VOL(3,9)	0.00	-0.60	-3.71	-0.39	-0.74*	-1.12**	-3.51	-1.10
VOL(3,12)	0.64**	-0.20	-4.05	-1.05	0.35**	-0.61**	-3.35	-1.41
CF-TECH$^{\text{MEAN}}$	0.45*	-0.52	-2.24	-0.10	0.13**	-0.07**	-4.97	-2.38
CF-TECH$^{\text{WEIG}}_{\theta=1}$	0.45*	-0.53	-2.28	-0.12	0.12**	-0.10**	-4.83	-2.35
CF-TECH$^{\text{WEIG}}_{\theta=0.9}$	0.46*	-0.53	-2.29	-0.11	0.12**	-0.11**	-4.82	-2.34
				Panel C: All predictors taken together				
CF-ALL$^{\text{MEAN}}$	0.89***	-0.99	-1.72	-0.10	1.17***	1.33***	-1.59	-0.76
CF-ALL$^{\text{WEIG}}_{\theta=1}$	0.89**	-0.97	-1.45	-0.09	1.07***	1.36***	-1.49	-0.73
CF-ALL$^{\text{WEIG}}_{\theta=0.9}$	0.90**	-0.97	-1.41	-0.08	1.03***	1.34***	-1.44	-0.73

Table A.2
Annualized gains in CER

This table reports the annualized gain in certainty equity return (CER) relative to the CER from the historical mean (in percent). ΔCER is estimated for a mean-variance investor with a relative risk aversion of three who allocates each month between the S&P 500 index and the risk-free rate. The optimal weight is estimated according to forecasts of one-month ahead excess returns from predictive regression models. The optimal weight in risky assets is constrained to lie between -0.5 and 1.5. The out-of-sample period runs from 1966:1 to 2017:12.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
				1966:1 to 2017:12				
Predictor	Basic	Basic$^{\text{NL}}$	D_H	D_H^{NL}	D_M	D_M^{NL}	D_L	D_L^{NL}
				Panel A: Economic variables				
DP	-1.17	0.95	-3.58	-3.06	-0.13	0.05	0.63	1.12**
DY	-1.10	1.17*	-5.19	-2.56	-1.20	-0.31	0.73	1.25**
EP	0.26	0.72	-0.46	-0.52	0.38	1.01	-0.80	-0.07
DE	-0.75	0.08	0.77	0.30	-0.78	0.59	-0.01	0.74
RVOL	-0.55	0.59*	0.23	0.01	-1.28	0.07	-0.39	-0.13
BM	-0.66	0.35	-3.55	-3.66	0.06	0.28	-0.99	-0.83
NTIS	0.51	-0.54	1.51*	0.80**	0.93	-0.81	-1.12	-0.02
TBL	1.99	-0.51	1.06	-0.68	2.65	1.39	0.81	-0.78
LTY	1.21	-0.84	4.09***	1.58	2.43	-0.47	0.40	-0.89
LTR	2.06*	1.47*	0.26	0.75	1.82	1.36	0.58	0.51
TMS	3.66**	1.28	-1.55	-0.89	0.54	1.15	1.87	0.60
DFY	-1.03	-0.51	-0.98	-0.63	0.11	0.82	-1.75	-1.06
DFR	0.54	0.04	-0.44	-0.40	0.19	1.06	1.11	0.91
INFL	0.49	-0.59	0.51	1.19***	2.60*	0.70	2.09	-0.28
CF-ECON$^{\text{MEAN}}$	1.73**	0.86	-1.23	-1.66	2.62**	0.98	0.64	0.47
CF-ECON$^{\text{WEIG}}_{\theta=1}$	1.93**	1.11*	-0.54	-1.03	2.62**	1.21	0.72	0.51
CF-ECON$^{\text{WEIG}}_{\theta=0.9}$	1.98**	1.22*	-0.46	-1.00	2.51**	1.21	0.74	0.55
				Panel B: Technical indicators				
MA(1,9)	1.55	1.92**	-3.26	-1.65	3.24	4.26**	-0.28	0.39
MA(1,12)	2.78*	2.29*	-2.69	-1.30	4.51**	3.64**	0.24	0.43
MA(2,9)	1.74	2.17**	-2.62	-1.64	3.32	4.09**	0.15	0.46
MA(2,12)	2.91*	2.45*	-2.11	-1.21	4.55**	3.57**	-0.04	0.54
MA(3,9)	2.29	2.44**	-2.10	-1.17	3.22*	3.62**	0.15	0.32
MA(3,12)	0.96	1.28*	-1.97	-1.25	3.44*	2.94**	-0.04	0.43
MOM(9)	1.16	1.06	-1.66	-1.04	4.12**	2.93**	-0.08	0.45
MOM(12)	1.09	0.93	-1.54	-0.27	2.80**	2.55**	-0.09	0.81
VOL(1,9)	1.21	1.77**	-1.01	-0.44	3.59*	3.41**	1.71	1.57
VOL(1,12)	1.89	2.06**	-1.27	-0.87	5.21**	3.60**	1.47	1.45
VOL(2,9)	1.32	1.41**	-1.90	-1.01	4.42**	3.49**	0.71	0.67
VOL(2,12)	1.52*	1.13*	-2.15	-1.23	4.72**	3.19**	1.47	1.48
VOL(3,9)	0.72	1.33**	-1.84	-0.99	4.28**	3.58**	1.39	1.39
VOL(3,12)	2.22*	2.18**	-1.81	-1.30	4.39**	3.04**	0.99	1.18
CF-TECH$^{\text{MEAN}}$	1.77*	1.78**	-2.22	-1.40	4.94**	4.00**	0.76	0.83
CF-TECH$^{\text{WEIG}}_{\theta=1}$	1.78*	1.79**	-2.19	-1.39	4.94**	3.99**	0.79	0.84
CF-TECH$^{\text{WEIG}}_{\theta=0.9}$	1.78*	1.79**	-2.19	-1.40	4.96**	4.01**	0.78	0.85
				Panel C: All predictors taken together				
CF-ALL$^{\text{MEAN}}$	1.72**	1.40**	-2.07	-1.76	5.00***	3.48***	0.75	0.58
CF-ALL$^{\text{WEIG}}_{\theta=1}$	1.80**	1.50**	-1.74	-1.48	5.09***	3.65***	0.85	0.62
CF-ALL$^{\text{WEIG}}_{\theta=0.9}$	1.83**	1.56**	-1.74	-1.47	5.07***	3.65***	0.88	0.67

Table A.4

Out-of-sample R^2 statistics (in %) - 1990:1 to 2017:12

This table presents statistics on the out-of-sample predictability of one month ahead log excess returns on the S&P 500 index. Panel A (Panel B) shows results for economic variables (technical indicators). In addition to the individual forecasts, I display results for three different combination forecasting methods. Panel C shows results when combining both sets of predictors. For each model the out-of-sample R^2 (in %) is displayed (Campbell and Thompson, 2008). *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively according to the Clark and West (2007) MSFE-adjusted statistic. The null hypothesis is equal MSFE and the alternative is that the more sophisticated model has smaller MSFE than the historical mean benchmark. Column (1) shows the respective predictor and column (2) shows results for the unadjusted series. Columns (3) to (9) present results for the frequency-decomposed predictors. D_H refers to components with periodicities between 2 to 16 months, D_M refers to components with periodicities between 16 to 64 months, and D_L captures oscillations above 64 months. The superscript NL indicates that the nonlinear forecasting model is applied in columns (3), (5), (7), and (9).

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
				1990:1 to 2017:12				
Predictor	Basic	Basic$^{\text{NL}}$	D_H	D_H^{NL}	D_M	D_M^{NL}	D_L	D_L^{NL}
				Panel A: Economic variables				
DP	-1.71	0.79**	-44.16	-25.71	-0.49	-0.18	-0.48	0.24
DY	-1.87	1.04**	-27.84	-10.93	-2.01	-0.53	-0.49	0.29
EP	-0.58	-0.27	-39.36*	-21.91	-0.66	0.15	-0.85	-0.29
DE	-2.04	-0.25	-24.28	-13.21	-4.03	-0.63	-0.57	0.25
RVOL	-0.52	0.08	-3.27	-1.76	-1.26	-0.58	-0.92	-0.55
BM	-0.41	0.17	-16.75	-8.07	0.01	0.16*	-0.59	-0.44
NTIS	-1.86	-1.36	0.10	-0.06	-4.89	-3.59	-0.81	0.05
TBL	-0.57	-0.86	-1.14	-1.16	-6.83	-3.17	0.21	-0.16
LTY	0.11	-0.34	-0.37	-0.58	-0.71	-0.47	0.06	-0.18
LTR	-0.52	0.21	-0.32	0.36	-2.14	-0.63	0.15	0.01
TMS	-1.46	-0.51	-1.03	-0.67	-7.04	-2.62	0.26*	0.21**
DFY	-0.85	-0.52	-13.21	-11.02	-6.05	-2.72	-1.04	-0.47
DFR	-0.49	-0.53	-0.83	-0.81	-7.84	0.69	-0.10	-0.01
INFL	-1.17	-1.40	0.85**	1.30***	-1.03	-0.60	0.55*	-0.02
CF-ECON$^{\text{MEAN}}$	-0.31	-0.13	-2.19	-2.02	-1.07	-0.50	-0.06	0.01
CF-ECON$^{\text{WEIG}}_{\theta=1}$	-0.27	-0.11	-1.32	-1.18	-0.95	-0.36	-0.06	0.00
CF-ECON$^{\text{WEIG}}_{\theta=0.9}$	-0.28	-0.11	-1.28	-1.23	-0.99	-0.36	-0.06	0.01
				Panel B: Technical indicators				
MA(1,9)	0.69*	0.71*	-4.66	-1.56	-1.36*	3.27**	-6.71	-1.87
MA(1,12)	0.77	0.96*	-2.75	-1.15	0.49*	2.57**	-7.22	-2.27
MA(2,9)	0.24	0.87*	-3.31	-1.62	-1.29	2.65**	-5.73	-1.76
MA(2,12)	0.81	1.04*	-2.09	-0.89	0.91**	2.48**	-6.61	-2.10
MA(3,9)	-0.16	0.62	-1.45	-0.86	-0.39	2.47**	-5.25	-1.97
MA(3,12)	0.01	0.38	-1.40	-0.79	0.90*	2.09**	-6.22	-2.32
MOM(9)	0.37	0.53	-2.10	-1.14	1.46**	2.15**	-5.69	-2.07
MOM(12)	0.43	0.48	-2.25	-1.12	1.12*	1.50**	-5.24	-1.87
VOL(1,9)	0.29	0.54	-1.30	-0.76	-2.38*	1.71*	-0.72	-0.17
VOL(1,12)	0.59	0.67	-1.23	-0.77	0.15**	1.90*	-1.11	-0.52
VOL(2,9)	0.25	0.37	-1.01	-0.35	-1.08*	1.56*	-1.04	-0.63
VOL(2,12)	0.90*	0.54	-2.62	-0.93	0.63**	1.59*	-0.44	-0.52
VOL(3,9)	0.14	0.34	-2.09	-0.77	-0.96	1.77*	-0.93	-0.41
VOL(3,12)	1.11*	0.86*	-1.71	-1.05	0.71**	1.61*	-0.74	-0.56
CF-TECH$^{\text{MEAN}}$	0.59	0.66	-1.15	-0.83	0.69*	2.25**	-3.20	-1.25
CF-TECH$^{\text{WEIG}}_{\theta=1}$	0.60	0.66	-1.12	-0.82	0.65*	2.25**	-3.12	-1.25
CF-TECH$^{\text{WEIG}}_{\theta=0.9}$	0.60	0.66	-1.12	-0.83	0.65*	2.25**	-3.10	-1.23
				Panel C: All predictors taken together				
CF-ALL$^{\text{MEAN}}$	0.24	0.30	-1.41	-1.35	0.70*	1.24**	-0.56	-0.34
CF-ALL$^{\text{WEIG}}_{\theta=1}$	0.26	0.31	-1.02	-0.95	0.78*	1.37**	-0.52	-0.39
CF-ALL$^{\text{WEIG}}_{\theta=0.9}$	0.26	0.32	-0.99	-0.97	0.75*	1.38**	-0.49	-0.35

Table A.5

Annualized gains in CER - 1990:1 to 2017:12

This table reports the annualized gain in certainty equity return (CER) relative to the CER from the historical mean (in percent). ΔCER is estimated for a mean-variance investor with a relative risk aversion of five who allocates each month between the S&P 500 index and the risk-free rate. The optimal weight is estimated according to forecasts of one-month ahead excess returns from predictive regression models. The optimal weight in risky assets is constrained to lie between 0 and 1.5. The out-of-sample period runs from 1990:1 to 2017:12.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
				1990:1 to 2017:12				
Predictor	Basic	Basic$^{\text{NL}}$	D_H	D_H^{NL}	D_M	D_M^{NL}	D_L	D_L^{NL}
				Panel A: Economic variables				
DP	-1.86	1.73**	-3.46	-1.48	-0.32	-0.15	-0.40	0.84
DY	-1.58	2.18**	-3.85	-0.52	-2.31	-0.45	-0.38	1.00
EP	1.77	2.25*	3.15	2.56*	0.53	0.97*	-0.72	0.12
DE	-2.05	-0.19	-3.32	-1.68	-2.07	0.38	-0.19	0.58
RVOL	-2.42	-0.60	-0.86	-0.69	-1.38	-0.44	-0.66	-0.46
BM	-0.53	0.70	-4.39	-1.51	-0.24	-0.04	-0.47	-0.37
NTIS	-0.62	-0.59	0.55	0.06	-3.02	-2.01	0.47	1.33
TBL	-0.00	-0.84	-1.39	-1.28	-3.18	-0.88	0.27	-0.34
LTY	-0.04	-0.47	-0.33	-0.34	-0.84	-0.84	-0.12	-0.29
LTR	-0.70	0.28	-0.47	0.21	0.02	0.34	0.15	-0.02
TMS	-0.44	-0.53	-1.26	-0.70	-3.81	-0.77	0.79**	0.13
DFY	-1.16	-0.72	-1.59	-1.13	-3.69	-0.54	0.02	0.57
DFR	0.42	0.47	-1.12	-1.05	-0.76	1.28	1.83	1.90
INFL	-1.07	-1.13	1.83	2.21***	1.30	1.54	0.80	0.16
CF-ECON$^{\text{MEAN}}$	-0.59	-0.29	-1.17	-0.81	-1.17	-0.71	0.47	0.55
CF-ECON$^{\text{WEIG}}_{\theta=1}$	-0.51	-0.24	-0.34	-0.21	-0.92	-0.49	0.46	0.55
CF-ECON$^{\text{WEIG}}_{\theta=0.9}$	-0.53	-0.24	-0.33	-0.26	-0.89	-0.47	0.47	0.56
				Panel B: Technical indicators				
MA(1,9)	2.06*	2.04*	-2.47	-0.37	3.11	3.77**	1.97	2.47
MA(1,12)	3.20*	3.19*	-1.14	-0.35	3.34*	3.44*	1.75	2.19
MA(2,9)	1.94	2.67*	-1.75	-0.46	1.97	3.46**	1.97	2.21
MA(2,12)	3.20*	3.28*	-0.89	-0.24	3.41*	3.39**	1.83	2.17
MA(3,9)	1.69	2.42*	-0.94	-0.29	2.12	2.98*	1.56	1.94
MA(3,12)	1.52	1.82	-0.12	-0.20	2.72	2.91*	1.54	1.97
MOM(9)	2.07	2.08	-0.33	-0.47	3.34*	2.97*	1.34	2.05
MOM(12)	1.93	1.96	-0.95	-0.59	2.41	2.91*	1.76	2.02
VOL(1,9)	1.55	1.94*	-0.45	-0.21	3.38	3.25*	2.89*	2.51
VOL(1,12)	2.39	2.63*	-0.61	-0.13	4.76***	3.40**	2.52	2.44
VOL(2,9)	1.39	1.83	-0.64	-0.11	3.21	2.66	2.23	2.20
VOL(2,12)	2.11	2.06*	-1.09	-0.43	4.08**	2.75*	2.76*	2.18
VOL(3,9)	1.02	1.34	-0.94	-0.13	2.84	2.86	2.22*	2.25
VOL(3,12)	2.80*	2.75*	-0.70	-0.42	3.90**	2.83*	2.71*	2.24
CF-TECH$^{\text{MEAN}}$	2.14	2.25*	-0.37	-0.21	3.57*	3.26**	2.23	2.21
CF-TECH$^{\text{WEIG}}_{\theta=1}$	2.15	2.26*	-0.33	-0.20	3.55*	3.27**	2.25	2.23
CF-TECH$^{\text{WEIG}}_{\theta=0.9}$	2.15	2.26*	-0.33	-0.20	3.56*	3.27**	2.25	2.23
				Panel C: All predictors taken together				
CF-ALL$^{\text{MEAN}}$	0.96	0.99	-1.02	-1.01	2.98*	2.96**	2.18	1.89
CF-ALL$^{\text{WEIG}}_{\theta=1}$	1.04	1.05	-0.79	-0.75	2.95*	3.01**	2.17	1.87
CF-ALL$^{\text{WEIG}}_{\theta=0.9}$	1.04	1.06	-0.83	-0.80	2.95*	3.01**	2.19	1.89

Table A.6

Annualized gains in SR - 1990:1 to 2017:12

This table reports the annualized gain in the Sharpe ratio (SR) relative to the SR from the historical mean. ΔSR is estimated for a mean-variance investor with a relative risk aversion of five who allocates each month between the S&P 500 index and the risk-free rate. The optimal weight is estimated according to forecasts of one-month ahead excess returns from predictive regression models. The optimal weight in risky assets is constrained to lie between 0 and 1.5. The out-of-sample period runs from 1990:1 to 2017:12.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
				1990:1 to 2017:12				
Predictor	Basic	Basic$^{\text{NL}}$	D_H	D_H^{NL}	D_M	D_M^{NL}	D_L	D_L^{NL}
				Panel A: Economic variables				
DP	-0.32	0.14**	-0.17	-0.07	-0.04	-0.01	-0.05	0.06
DY	-0.28	0.18**	-0.22	-0.01	-0.20	-0.01	-0.05	0.07
EP	0.19*	0.19*	0.24	0.21*	0.04	0.07*	-0.06	0.00
DE	-0.20	-0.01	-0.19	-0.09	-0.13	0.03	-0.04	0.04
RVOL	-0.15	-0.02	-0.05	-0.03	-0.08	-0.01	-0.05	-0.03
BM	-0.07	0.05	-0.26	-0.10	-0.02	0.00	-0.00	-0.03
NTIS	-0.04	-0.04	0.04	0.01	-0.22	-0.13	0.03	0.10
TBL	0.04	-0.05	-0.09	-0.08	-0.15	-0.03	0.04*	-0.02
LTY	0.02	-0.03	-0.01	-0.02	-0.02	-0.04	-0.00	-0.02
LTR	-0.04	0.03	-0.03	0.02	0.02	0.03	0.02	0.00
TMS	0.00	-0.03	-0.10	-0.05	-0.23	-0.03	0.07**	0.01
DFY	-0.10	-0.05	-0.09	-0.07	-0.22	-0.02	-0.00	0.04
DFR	0.03	0.03	-0.08	-0.07	-0.07	0.10	0.14	0.15
INFL	-0.06	-0.08	0.14	0.17***	0.10	0.12	0.08*	0.01
CF-ECON$^{\text{MEAN}}$	-0.06	-0.02	-0.07	-0.04	-0.07	-0.03	0.04	0.04
CF-ECON$^{\text{WEIG}}_{\theta=1}$	-0.05	-0.02	-0.03	-0.01	-0.06	-0.02	0.03	0.04
CF-ECON$^{\text{WEIG}}_{\theta=0.9}$	-0.05	-0.02	-0.03	-0.01	-0.06	-0.02	0.04	0.04
				Panel B: Technical indicators				
MA(1,9)	0.17*	0.17**	-0.15	-0.03	0.25	0.33**	0.16	0.21
MA(1,12)	0.27*	0.28**	-0.06	-0.02	0.27	0.31**	0.14	0.18
MA(2,9)	0.16	0.23**	-0.11	-0.03	0.16	0.31	0.16**	0.18
MA(2,12)	0.27*	0.29**	-0.05	-0.02	0.29*	0.30**	0.15	0.18
MA(3,9)	0.13	0.20*	-0.05	-0.02	0.17	0.26*	0.13	0.15
MA(3,12)	0.12	0.15	0.01	-0.01	0.22	0.25*	0.13	0.16
MOM(9)	0.17	0.17*	-0.01	-0.03	0.28*	0.26*	0.12	0.17
MOM(12)	0.16	0.16*	-0.06	-0.04	0.20	0.25*	0.15	0.16
VOL(1,9)	0.12	0.16*	-0.01	-0.01	0.27	0.28*	0.23	0.21
VOL(1,12)	0.20	0.22*	-0.03	-0.01	0.40**	0.30**	0.20	0.20
VOL(2,9)	0.11	0.15	-0.03	-0.00	0.26	0.22	0.18	0.18
VOL(2,12)	0.17	0.17*	-0.06	-0.03	0.33**	0.23*	0.22	0.18
VOL(3,9)	0.08	0.10*	-0.05	-0.01	0.23	0.24*	0.18	0.18
VOL(3,12)	0.23*	0.23**	-0.05	-0.03	0.32**	0.24*	0.21	0.18
CF-TECH$^{\text{MEAN}}$	0.17	0.19*	-0.01	-0.01	0.30*	0.28**	0.18	0.18
CF-TECH$^{\text{WEIG}}_{\theta=1}$	0.18	0.19*	-0.01	-0.01	0.30*	0.29**	0.18	0.18
CF-TECH$^{\text{WEIG}}_{\theta=0.9}$	0.18	0.19*	-0.01	-0.01	0.30*	0.29**	0.18	0.18
				Panel C: All predictors taken together				
CF-ALL$^{\text{MEAN}}$	0.07	0.07*	-0.06	-0.06	0.25*	0.25**	0.17	0.15
CF-ALL$^{\text{WEIG}}_{\theta=1}$	0.08	0.08*	-0.05	-0.05	0.25*	0.26**	0.17	0.15
CF-ALL$^{\text{WEIG}}_{\theta=0.9}$	0.08	0.08*	-0.05	-0.05	0.25*	0.26**	0.17	0.15

Table A.7

Out-of-sample R^2 statistics (in %) - principal component analysis

This table presents statistics on the out-of-sample predictability of one month ahead log excess returns on the S&P 500 index. Panel A (Panel B) shows results for economic variables (technical indicators). Panel C shows results for all predictors taken together. I display results for the first, second, and third principal component. For each model the out-of-sample R^2 (in %) is displayed (Campbell and Thompson, 2008). *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively according to the Clark and West (2007) MSFE-adjusted statistic. The null hypothesis is equal MSFE and the alternative is that the more sophisticated model has smaller MSFE than the historical mean benchmark. Column (1) shows the respective predictor and column (2) shows results for the unadjusted series. Columns (3) to (9) present results for the frequency-decomposed predictors. D_H refers to components with periodicities between 2 to 16 months, D_M refers to components with periodicities between 16 to 64 months, and D_L captures oscillations above 64 months. The superscript NL indicates that the nonlinear forecasting model is applied in columns (3), (5), (7), and (9).

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
				1966:1 to 2017:12				
Predictor	Basic	Basic$^{\text{NL}}$	D_H	D_H^{NL}	D_M	D_M^{NL}	D_L	D_L^{NL}
				Panel A: Economic variables				
PC-ECON$_1$	1.24***	0.75**	-29.85	-15.51	0.16**	0.62*	-0.48	-0.81
PC-ECON$_2$	-6.80	-1.98	-33.10	-12.46	-12.49	-4.12	-1.59	-0.83
PC-ECON$_3$	-15.37	-5.25	-9.75	-3.58	-3.69	-1.92	-3.32	0.35
				Panel B: Technical indicators				
PC-TECH$_1$	0.52*	0.88**	-5.56	-3.41	-0.04***	2.04***	-6.86	-3.34
PC-TECH$_2$	0.24	0.39	-0.17	0.65***	-2.96**	1.41***	-0.00*	-0.95
PC-TECH$_3$	-5.64	-3.56	-0.45	-0.21	-188.19	-74.03	-64.72	-28.94
				Panel C: All predictors taken together				
PC-ALL$_1$	0.35	0.52	-11.77	-6.28	-0.22**	1.57**	-5.76	-3.06
PC-ALL$_2$	-3.16	-1.25	-3.13	-0.70	-18.43	-8.67	-3.01	-0.96
PC-ALL$_3$	-2.75	-1.43	-10.20	-1.62*	-3.27	-0.37	-1.63	-0.48

Table A.8

Annualized gains in CER - principal component analysis

This table reports the annualized gain in certainty equity return (CER) relative to the CER from the historical mean (in percent). ΔCER is estimated for a mean-variance investor with a relative risk aversion of five who allocates each month between the S&P 500 index and the risk-free rate. The optimal weight is estimated according to forecasts of one-month ahead excess returns from predictive regression models. The optimal weight in risky assets is constrained to lie between 0 and 1.5 to prevent shorting stocks and leveraging more than 50%. The out-of-sample period runs from 1966:1 to 2017:12.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
				1966:1 to 2017:12				
Predictor	Basic	Basic$^{\text{NL}}$	D_H	D_H^{NL}	D_M	D_M^{NL}	D_L	D_L^{NL}
				Panel A: Economic variables				
PC-ECON$_1$	2.09**	1.23**	-2.24	-0.75	1.04	0.64	1.18	0.11
PC-ECON$_2$	-0.65	0.40	-2.34	-0.60	-0.52	-0.22	0.54	-0.12
PC-ECON$_3$	-2.53	-1.23	-1.00	-0.22	-0.48	0.37	-0.22	2.27**
				Panel B: Technical indicators				
PC-TECH$_1$	2.07*	2.35***	-1.49	-1.03	3.75***	3.00***	0.33	1.22
PC-TECH$_2$	1.57*	1.32**	0.40	0.76***	3.56**	2.99***	1.43	0.31
PC-TECH$_3$	-2.37	-2.28	-0.26	-0.02	-3.09	-1.13	1.97	1.72
				Panel C: All predictors taken together				
PC-ALL$_1$	1.94*	2.03**	-2.35	-2.02	3.26**	2.68**	0.36	1.10
PC-ALL$_2$	0.00	1.15	-0.74	-0.06	-1.00	-1.24	-1.94	0.15
PC-ALL$_3$	1.36	1.15*	-0.36	0.47	-0.58	-0.06	-0.03	-0.28

Table A.9

Annualized gains in SR - principal component analysis

This table reports the annualized gain in the Sharpe ratio (SR) relative to the SR from the historical mean. ΔSR is estimated for a mean-variance investor with a relative risk aversion of five who allocates each month between the S&P 500 index and the risk-free rate. The optimal weight is estimated according to forecasts of one-month ahead excess returns from predictive regression models. The optimal weight in risky assets is constrained to lie between 0 and 1.5 to prevent shorting stocks and leveraging more than 50%. The out-of-sample period runs from 1966:1 to 2017:12.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
				1966:1 to 2017:12				
Predictor	Basic	Basic$^{\text{NL}}$	D_H	D_H^{NL}	D_M	D_M^{NL}	D_L	D_L^{NL}
				Panel A: Economic variables				
PC-ECON$_1$	0.14**	0.09*	-0.05	-0.02	0.11*	0.07*	0.06	-0.02
PC-ECON$_2$	-0.00	0.04	-0.07	-0.02	-0.02	-0.00	0.04	-0.01
PC-ECON$_3$	-0.14	-0.06	-0.01	0.02	-0.04	0.03	-0.09	0.17**
				Panel B: Technical indicators				
PC-TECH$_1$	0.15*	0.17**	-0.06	-0.08	0.29***	0.23***	0.07	0.07
PC-TECH$_2$	0.10	0.08*	0.02	0.06***	0.28***	0.23***	0.11	0.01
PC-TECH$_3$	-0.15	-0.10	-0.01	0.00	-0.10	-0.02	0.16	0.13
				Panel C: All predictors taken together				
PC-ALL$_1$	0.14*	0.14**	-0.09	-0.11	0.26**	0.20**	0.06	0.06
PC-ALL$_2$	-0.03	0.07	-0.02	-0.00	-0.04	-0.07	-0.13	0.01
PC-ALL$_3$	0.12	0.09*	0.02	0.05	-0.00	0.01	0.07	0.02

Table A.10

Results for different wavelet filters from combined forecasts of medium-frequency components

This table presents results on the out-of-sample performance of combination forecasts from economic variables and technical indicators for different wavelets. Panel A presents results for R^2_{OS}, whereas Panel B (Panel C) shows the annualized ΔCER (monthly ΔSR). The respective wavelets are the Daubechies wavelet with width 4 and 8 (D(4) and D(8)), the Fejér-Korovkin wavelet with width 4 (FK(4)), and the least asymmetric wavelet with width 16 (LA(16)).The out-of-sample period runs from 1966:1 to 2017:12.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Panel A: R^2_{OS}							
	D_M				D_M^{NL}			
Predictor	D(4)	D(8)	FK(4)	LA(16)	D(4)	D(8)	FK(4)	LA(16)
CF-ECON$^{\text{MEAN}}$	1.13***	1.02***	1.26***	0.95***	0.39	0.34	0.43	0.32
CF-TECH$^{\text{MEAN}}$	0.29***	0.19***	0.33***	0.07***	1.93***	1.85***	1.97***	1.76***
CF-ALL$^{\text{MEAN}}$	1.53***	1.43***	1.60***	1.32***	1.46***	1.38***	1.49***	1.31***
	Panel B: ΔCER							
	D_M							
Predictor	D(4)	D(8)	FK(4)	LA(16)				
CF-ECON$^{\text{MEAN}}$	2.07**	1.93**	2.23**	1.91**				
CF-TECH$^{\text{MEAN}}$	3.93***	3.84***	3.83***	3.70***				
CF-ALL$^{\text{MEAN}}$	4.31***	4.07***	4.34***	3.85***				
	Panel C: ΔSR							
	D_M							
Predictor	D(4)	D(8)	FK(4)	LA(16)				
CF-ECON$^{\text{MEAN}}$	0.05**	0.05**	0.05***	0.05**				
CF-TECH$^{\text{MEAN}}$	0.09***	0.09***	0.09***	0.08***				
CF-ALL$^{\text{MEAN}}$	0.10***	0.09***	0.10***	0.09***				

Table A.11
Relative average turnover

This table reports the average turnover of a portfolio based on a sophisticated forecasting model relative to the average turnover of a portfolio based on the historical mean forecast. Turnover is defined as the percentage of wealth traded at the end of each period. The out-of-sample period runs from 1966:1 to 2017:12.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
			1966:1 to 2017:12					
Predictor	Basic	Basic$^{\text{NL}}$	D_H	D_H^{NL}	D_M	D_M^{NL}	D_L	D_L^{NL}
			Panel A: Economic variables					
DP	2.03	2.45	16.87	4.54	1.77	1.62	1.56	1.77
DY	2.79	2.90	16.92	4.39	2.66	2.26	1.62	1.83
EP	1.63	2.08	13.21	4.55	2.44	2.01	1.46	1.62
DE	2.02	2.21	3.86	2.34	2.93	3.13	1.65	1.87
RVOL	4.07	2.44	11.44	3.51	3.08	2.06	1.87	1.57
BM	2.32	2.40	15.37	4.61	1.87	1.77	1.68	1.82
NTIS	3.09	2.22	6.58	1.94	3.30	3.03	2.16	1.59
TBL	1.44	2.52	6.16	3.37	2.93	3.51	1.13	2.46
LTY	1.03	2.53	10.46	4.21	3.14	2.75	1.10	2.41
LTR	22.89	6.12	20.18	5.92	10.83	4.20	3.34	2.14
TMS	4.15	3.79	5.90	2.44	4.03	3.45	2.21	2.45
DFY	2.52	2.13	11.84	4.34	3.22	3.01	1.33	2.12
DFR	10.04	4.30	8.25	4.12	12.45	5.08	5.67	2.76
INFL	7.59	3.52	5.39	1.74	8.01	3.40	1.59	2.41
CF-ECON$^{\text{MEAN}}$	3.94	2.47	9.05	3.51	3.56	2.96	1.94	1.99
CF-ECON$^{\text{WEIG}}_{\theta=1}$	4.21	2.59	8.54	3.41	3.95	3.03	2.04	2.02
CF-ECON$^{\text{WEIG}}_{\theta=0.9}$	4.32	2.63	8.42	3.35	4.21	3.08	2.11	2.03
			Panel B: Technical indicators					
MA(1,9)	4.30	2.34	8.44	2.82	5.75	3.17	3.51	2.92
MA(1,12)	4.00	2.54	5.95	2.60	4.12	2.97	3.24	2.97
MA(2,9)	4.39	2.30	7.37	2.65	5.01	2.98	3.06	2.91
MA(2,12)	3.74	2.47	4.94	2.31	3.83	2.74	3.03	2.97
MA(3,9)	4.54	2.62	5.98	2.49	4.91	2.99	3.14	3.01
MA(3,12)	2.73	2.10	5.56	2.61	3.68	2.62	3.11	2.96
MOM(9)	2.62	1.82	6.53	2.76	3.48	2.50	3.09	2.97
MOM(12)	2.38	1.72	5.56	2.20	2.78	1.99	2.72	2.75
VOL(1,9)	5.67	2.33	11.36	3.25	5.71	3.65	3.05	2.76
VOL(1,12)	5.37	2.23	8.57	2.47	4.02	3.01	2.81	2.78
VOL(2,9)	3.70	1.94	7.67	2.66	4.93	3.22	3.21	2.88
VOL(2,12)	2.74	1.76	5.83	2.52	4.04	2.97	2.60	2.60
VOL(3,9)	2.91	1.83	6.91	2.76	4.60	3.25	2.88	2.73
VOL(3,12)	3.24	2.14	4.94	2.34	3.75	2.74	2.77	2.79
CF-TECH$^{\text{MEAN}}$	3.20	2.01	6.36	2.60	4.11	2.75	2.70	2.67
CF-TECH$^{\text{WEIG}}_{\theta=1}$	3.21	2.02	6.45	2.61	4.09	2.74	2.73	2.69
CF-TECH$^{\text{WEIG}}_{\theta=0.9}$	3.22	2.02	6.47	2.61	4.11	2.74	2.75	2.69
			Panel C: All predictors taken together					
CF-ALL$^{\text{MEAN}}$	2.95	2.03	7.61	3.07	3.63	2.79	2.40	2.46
CF-ALL$^{\text{WEIG}}_{\theta=1}$	3.14	2.13	7.13	2.89	3.79	2.82	2.51	2.47
CF-ALL$^{\text{WEIG}}_{\theta=0.9}$	3.24	2.17	7.09	2.88	3.94	2.87	2.57	2.46

Table A.12

Annualized gains in CER after transaction costs

This table reports the annualized gain in certainty equity return (CER) relative to the CER from the historical mean (in percent). Results are net of a proportional transaction cost of 50 basis points per transaction. ΔCER is estimated for a mean-variance investor with a relative risk aversion of five who allocates each month between the S&P 500 index and the risk-free rate. The optimal weight is estimated according to forecasts of one-month ahead excess returns from predictive regression models. The optimal weight in risky assets is constrained to lie between 0 and 1.5 to prevent shorting stocks and leveraging more than 50%. The out-of-sample period runs from 1966:1 to 2017:12.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
				1966:1 to 2017:12				
Predictor	Basic	Basic$^{\text{NL}}$	D_H	D_H^{NL}	D_M	D_M^{NL}	D_L	D_L^{NL}
				Panel A: Economic variables				
DP	-0.78	0.35	-4.85	-3.58	0.09	0.05	0.57	0.84**
DY	-0.46	0.83	-5.97	-2.93	-1.54	-0.71	0.62	0.95**
EP	0.17	0.31	-2.22	-0.91	0.09	0.70	-0.31	-0.00
DE	-0.46	0.02	-0.47	-0.68	-1.26	-0.10	0.17	0.44
RVOL	-1.42	-0.17	-1.77	-0.96	-1.71	-0.70	-0.36	-0.06
BM	-1.41	-0.32	-5.10	-3.47	0.04	0.05	-0.69	-0.37
NTIS	-0.13	-1.06	0.05	0.00	-0.29	-1.81	-0.67	0.50
TBL	1.74	-0.21	0.49	-0.64	0.87	0.37	1.51	-0.20
LTY	1.65	-0.22	1.90**	0.63	2.12*	-0.20	1.14	-0.30
LTR	-1.98	0.16	-2.29	-0.02	0.21	0.39	0.22	0.21
TMS	1.39	0.56	-1.87	-1.11	-0.99	0.35	0.94	0.38
DFY	-0.97	-0.35	-1.70	-0.86	-1.30	0.09	0.13	-0.13
DFR	-1.02	-0.25	-1.58	-0.78	-0.47	0.69	0.20	0.97
INFL	-0.58	-0.86	0.17	1.09**	0.89	0.59	1.60*	-0.11
CF-ECON$^{\text{MEAN}}$	1.34**	0.47	-2.44	-2.30	1.99**	0.44	0.87	0.45
CF-ECON$^{\text{WEIG}}_{\theta=1}$	1.41**	0.62	-1.82	-1.76	2.01**	0.64	0.89	0.49
CF-ECON$^{\text{WEIG}}_{\theta=0.9}$	1.40**	0.67	-1.77	-1.77	1.97**	0.67	0.90	0.51
				Panel B: Technical indicators				
MA(1,9)	1.09	1.79**	-2.78	-1.23	2.27	3.24***	-0.38	0.92
MA(1,12)	2.19*	2.36**	-2.21	-1.09	3.13**	2.71**	-0.47	0.84
MA(2,9)	1.29	2.24***	-2.53	-1.34	2.47*	3.10***	0.09	1.02
MA(2,12)	2.29*	2.51**	-1.94	-1.02	3.22**	2.66**	-0.32	0.85
MA(3,9)	1.70	2.37***	-2.07	-1.07	2.26	2.67**	-0.22	0.68
MA(3,12)	0.92	1.36*	-1.12	-0.99	2.50*	2.10**	-0.52	0.72
MOM(9)	1.01	1.20	-1.52	-1.03	2.81**	2.12**	-0.58	0.70
MOM(12)	0.95	1.12	-1.35	-0.62	1.76*	1.90**	-0.47	0.97
VOL(1,9)	0.54	1.48**	-1.88	-0.89	2.67*	2.81**	0.69	1.44
VOL(1,12)	1.19	2.11**	-1.90	-0.89	4.06***	2.90***	0.57	1.41
VOL(2,9)	0.52	1.32**	-2.05	-0.99	3.14**	2.57**	0.03	1.09
VOL(2,12)	0.66	1.07	-2.00	-1.12	3.34**	2.41**	0.54	1.35
VOL(3,9)	0.36	1.16**	-1.81	-0.95	2.80*	2.57**	0.37	1.23
VOL(3,12)	1.57	2.12**	-1.44	-0.94	2.98**	2.26**	0.28	1.13
CF-TECH$^{\text{MEAN}}$	1.29	1.72**	-1.68	-1.09	3.30**	2.82***	0.17	0.98
CF-TECH$^{\text{WEIG}}_{\theta=1}$	1.30	1.73**	-1.68	-1.09	3.30**	2.83***	0.19	1.00
CF-TECH$^{\text{WEIG}}_{\theta=0.9}$	1.30	1.73**	-1.69	-1.09	3.30**	2.83***	0.18	1.00
				Panel C: All predictors taken together				
CF-ALL$^{\text{MEAN}}$	1.46***	1.10**	-2.71	-2.37	3.96***	2.69***	0.53	1.00
CF-ALL$^{\text{WEIG}}_{\theta=1}$	1.52**	1.20**	-2.15	-1.83	3.81***	2.71***	0.54	1.03
CF-ALL$^{\text{WEIG}}_{\theta=0.9}$	1.53**	1.24**	-2.13	-1.81	3.76***	2.71***	0.56	1.07

Table A.13
Annualized gains in SR after transaction costs

This table reports the annualized gain in the Sharpe ratio (SR) relative to the SR from the historical mean. Results are net of a proportional transaction cost of 50 basis points per transaction. ΔSR is estimated for a mean-variance investor with a relative risk aversion of five who allocates each month between the S&P 500 index and the risk-free rate. The optimal weight is estimated according to forecasts of one-month ahead excess returns from predictive regression models. The optimal weight in risky assets is constrained to lie between 0 and 1.5 to prevent shorting stocks and leveraging more than 50%. The out-of-sample period runs from 1966:1 to 2017:12.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
				1966:1 to 2017:12				
Predictor	Basic	Basic$^{\text{NL}}$	D_H	D_H^{NL}	D_M	D_M^{NL}	D_L	D_L^{NL}
				Panel A: Economic variables				
DP	-0.12	0.05	-0.21	-0.16	-0.02	0.01	0.02	0.05*
DY	-0.11	0.08	-0.29	-0.11	-0.12	-0.01	0.02	0.06*
EP	-0.02	0.02	-0.07	-0.04	0.01	0.04	-0.03	-0.01
DE	-0.07	-0.00	0.02	-0.00	-0.01	0.02	-0.03	0.01
RVOL	-0.01	0.04	-0.07	-0.01	-0.02	0.01	-0.04	-0.01
BM	-0.09	-0.01	-0.26	-0.18	-0.00	0.01	-0.03	-0.04
NTIS	0.04	-0.07	-0.00	0.00	0.03	-0.08	-0.06	0.01
TBL	0.12	-0.03	0.05	-0.02	0.13	0.05	0.08	-0.04
LTY	0.09	-0.04	0.16**	0.05	0.17**	-0.03	0.04	-0.05
LTR	-0.08	0.03	-0.14	0.01	0.06	0.05	0.02	0.01
TMS	0.17**	0.05	-0.14	-0.07	0.00	0.06	0.09	0.00
DFY	-0.03	-0.00	-0.05	-0.01	-0.01	0.06	-0.04	-0.04
DFR	-0.09	-0.02	-0.11	-0.05	0.00	0.06	-0.01	0.04
INFL	-0.05	-0.08	0.01	0.08**	0.07	0.05	0.12*	-0.03
CF-ECON$^{\text{MEAN}}$	0.07*	0.02	-0.12	-0.10	0.16**	0.05	0.03	0.00
CF-ECON$^{\text{WEIG}}_{\theta=1}$	0.08*	0.03	-0.10	-0.08	0.16**	0.06	0.04	0.00
CF-ECON$^{\text{WEIG}}_{\theta=0.9}$	0.08*	0.04	-0.10	-0.08	0.16**	0.06	0.04	0.01
				Panel B: Technical indicators				
MA(1,9)	0.06	0.12**	-0.17	-0.09	0.19*	0.25***	0.01	0.04
MA(1,12)	0.16*	0.16**	-0.14	-0.08	0.24**	0.20**	0.02	0.03
MA(2,9)	0.08	0.15**	-0.16	-0.10	0.19*	0.23***	0.05	0.05
MA(2,12)	0.17*	0.18**	-0.12	-0.08	0.25**	0.19**	0.03	0.04
MA(3,9)	0.12	0.17 **	-0.14	-0.08	0.18*	0.19**	0.03	0.02
MA(3,12)	0.05	0.08*	-0.06	-0.07	0.19**	0.14*	0.02	0.03
MOM(9)	0.06	0.07	-0.09	-0.08	0.21**	0.14*	0.01	0.03
MOM(12)	0.05	0.06	-0.09	-0.04	0.12	0.12*	0.03	0.05
VOL(1,9)	0.02	0.09*	-0.10	-0.07	0.22*	0.21**	0.07	0.09
VOL(1,12)	0.08	0.15**	-0.12	-0.07	0.32***	0.21***	0.07	0.09
VOL(2,9)	0.03	0.08*	-0.13	-0.08	0.25**	0.19**	0.03	0.06
VOL(2,12)	0.04	0.06	-0.12	-0.09	0.26***	0.17**	0.07	0.08
VOL(3,9)	0.02	0.07**	-0.10	-0.07	0.22**	0.19**	0.06	0.07
VOL(3,12)	0.11	0.15**	-0.10	-0.07	0.24**	0.16**	0.05	0.06
CF-TECH$^{\text{MEAN}}$	0.08	0.11**	-0.10	-0.09	0.26**	0.21***	0.05	0.05
CF-TECH$^{\text{WEIG}}_{\theta=1}$	0.08	0.11**	-0.10	-0.09	0.26**	0.21***	0.06	0.05
CF-TECH$^{\text{WEIG}}_{\theta=0.9}$	0.08	0.11**	-0.10	-0.09	0.26**	0.21***	0.06	0.05
				Panel C: All predictors taken together				
CF-ALL$^{\text{MEAN}}$	0.09**	0.06**	-0.14	-0.12	0.31***	0.20***	0.05	0.04
CF-ALL$^{\text{WEIG}}_{\theta=1}$	0.09**	0.07**	-0.12	-0.10	0.30***	0.20***	0.05	0.05
CF-ALL$^{\text{WEIG}}_{\theta=0.9}$	0.10**	0.07**	-0.12	-0.10	0.29***	0.20***	0.05	0.05