Forecast combination methods

The combinations of forecasts entertained in this study, $\hat{S}_{c,t+h|t}$, take the form of a linear combination of the predictions of individual specifications,

$$\hat{S}_{c,t+h|t} = w^h_{c,0t} + \sum_{m=1}^{M} w^h_{c,mt} \hat{S}_{m,t+h|t},$$

where c is the combination method, M is the number of individual forecasts, the weights are given by $\{w^h_{c,mt}\}^M_{m=0}$, and $\hat{S}_{m,t+h|t}$ is the individual exchange rate forecast. Table 6 lists the 13 forecast combination methods used.

	Forecasting combination based on
mean	mean of individual predictions
tmean	trimmed mean of individual predictions
median	median of individual predictions
OLS	pooling using OLS
PC	principal components
DMSFE	discounted mean square forecast errors
HR	hit rates
EHR	exponential of hit rates
EEDF	the economic evaluation of directional forecasts
BMA	Bayesian model averaging weights using the predictive likelihood
FMA-aic	frequentist model averaging with AIC weights
FMA-bic	frequentist model averaging with BIC weights
FMA-hq	frequentist model averaging with Hannan-Quinn weights

Table 6: Forecast combination methods.

Results for the forecast horizons of six and twelve months

	MV	CVaR, β	linear	LLA, λ		QLA, λ		USD	GBP	JPY	EW	USD	GBP	JPY	EW
		0.05		1.25	5.00	1.25	5.00					RW	RW	RW	RW
Performance measures															
Mean	0.38	0.46	-1.01	0.14	0.58	-1.02	0.03	-0.95	0.30	-0.29	-0.31	-1.13	-0.18	-3.39	-1.57_{1}
Omega	1.14	1.14	0.85	1.03	1.14	0.84	1.01	0.87	1.06	0.96	0.91_{1}	0.84	0.96	$0.64_{1,5}$	$0.58_{3,5}$
Sharpe ratio	0.05	0.04	-0.05	0.01	0.04	-0.06	0.00	-0.06	0.02	-0.01	-0.03	-0.07	-0.01	-0.16	-0.20
Sortino ratio	0.07	0.07	-0.08	0.01	0.07	-0.08	0.00	-0.08	0.04	-0.02	-0.05	-0.09	-0.02	-0.19	-0.23
Additional descriptive statistics															
Median	0.54	-0.97	-2.65	-0.46	-0.47	-2.05	-0.31	0.71	-2.35	0.77	-0.91	1.73	-2.19	0.40	-1.03
Volatility	5.79	7.71	13.06	10.86	9.51	12.10	10.91	11.47	9.14	14.95	6.47	11.46	9.14	14.76	5.50
Down. vol.	3.96	5.03	9.34	7.66	6.26	8.83	7.73	8.81	5.65	10.64	4.55	9.06	6.06	12.87	4.87
Down. vol. ratio	0.49	0.46	0.51	0.50	0.47	0.52	0.50	0.55	0.44	0.51	0.50	0.57	0.47	0.63	0.64
CVaR, $\beta = 0.05$	-18.24	-25.97	-44.25	-36.20	-30.89	-42.17	-37.22	-33.18	-23.06	-44.25	-20.27	-33.18	-24.27	-47.95	-22.83
Skewness	-0.13	0.31	0.11	-0.26	0.22	-0.08	-0.27	-0.29	0.66	-0.02	0.09	-0.42	0.52	-0.85	-0.96
Kurtosis	4.66	7.67	6.09	7.09	6.53	6.15	6.95	2.43	3.75	3.95	3.78	2.37	3.84	3.45	4.51
Break-even transaction costs															
USD	9.10	5.26	-0.70	2.44	5.13	-0.48	2.39								
GBP	2.57	1.36	-4.84	-1.08	1.14	-4.40	-1.70								
JPY	8.57	4.95	-1.04	2.15	4.81	-0.80	2.05								
EW	16.14	4.54	-6.40	0.07	4.28	-5.49	-0.71								
Break-even transaction costs (RW)															
USD	9.70	5.62	-0.32	2.76	5.50	-0.12	2.76								
GBP	3.58	1.97	-4.20	-0.54	1.76	-3.80	-1.07								
JPY	14.27	8.35	2.57	5.23	8.29	2.63	5.62								
EW	23.57	8.43	-0.93	3.78	8.33	-0.56	4.05								
Realized return															
Last 5 years	0.50	-0.10	-0.69	0.46	0.57	-1.19	0.60	0.30	-0.52	-0.66	0.07	0.00	-0.85	-3.80	-1.12
Last 3 years	1.22	0.12	-1.49	-0.09	0.15	-1.99	0.34	-2.27	3.08	-3.75	-0.67	-1.52	1.16	-5.89	-1.69
Last year	3.14	1.05	0.83	1.75	2.99	0.54	2.51	-9.04	10.21	-1.21	0.02	0.74	5.96	-1.21	2.13
Mean allocation															
USD	35.01	20.70	23.71	31.92	28.04	27.74	31.19	100	0	0	33.33	100	0	0	33.33
GBP	50.35	50.33	40.21	37.91	47.77	41.91	39.39	0	100	0	33.33	0	100	0	33.33
JPY	14.63	28.97	36.08	30.17	24.19	30.35	29.42	0	0	100	33.33	0	0	100	33.33

Table 7: *Optimal currency portfolios: Out-of-sample evaluation and comparison with benchmark portfolios (TS1, h=6).*

The table reports annual statistics of a monthly reallocated optimal currency portfolio and mean optimal weights, based on an optimization period of 36 months (rolling window), trading strategy 1 and a six-months forecast horizon. The evaluation period covers January 2008 to January 2016. Statistics are calculated on the basis of monthly returns and then annualized assuming discrete compounding. The same statistics are reported for the benchmark portfolios based on composite forecasts (i.e., the single assets of which the portfolios are constructed and the equally weighted portfolio) and for the benchmark portfolios based on the random walk. The sub-indices show the results of the bootstrap test. Their values indicate how many optimal portfolios outperform (in terms of the respective performance measure) that specific benchmark portfolio. If no sub-index is present, the benchmark portfolio is not outperformed by any of the optimal portfolios. If there is only one sub-index, its value indicates the number of optimal portfolios outperforming the benchmark portfolio at the 10% significance level. In the case of two sub-indices, the first one indicates the number of optimal portfolios outperforming the benchmark portfolio at the 5% significance level and the second one at the 10% significance level. Returns, weights and transaction costs are given in per cent.

	MV	CVaR, β	linear	LLA, λ		QLA, λ		USD	GBP	JPY	EW	USD	GBP	JPY	EW
		0.05		1.25	5.00	1.25	5.00					RW	RW	RW	RW
Performance measures															
Mean	-0.63	-0.13	-2.26	-1.21	-0.51	-1.91	-1.19	-1.27	0.44	-3.55_{2}	-1.47_{1}	-2.19	-1.45	$-5.17_{3,6}$	-2.94_{3}
Omega	0.81	0.97	0.62	0.76	0.87	0.65	0.77	0.82	1.09	$0.63_{1,2}$	$0.65_{1,2}$	0.71	0.75	$0.50_{1,5}$	$0.52_{1,4}$
Sharpe ratio	-0.08	-0.01	-0.16	-0.09	-0.05	-0.14	-0.09	-0.08	0.04	-0.18	-0.17	-0.14	-0.12	-0.26	-0.25
Sortino ratio	-0.11	-0.02	-0.19	-0.11	-0.06	-0.17	-0.12	-0.10	0.06	-0.22	-0.21	-0.18	-0.14	-0.29	-0.27
Additional descriptive statistics															
Median	-0.85	-0.68	-2.94	-1.11	-0.24	-2.58	-1.42	0.75	-2.54	-3.62	-1.46	-1.42	1.15	-3.80	-1.10
Volatility	5.39	6.65	10.20	9.54	7.61	9.63	9.19	11.30	8.93	14.46	6.16	11.22	8.88	14.21	8.42
Down. vol.	4.13	5.00	8.39	7.56	5.71	7.90	7.13	8.81	5.46	11.50	4.91	8.82	7.44	12.69	7.71
Down. vol. ratio	0.54	0.54	0.59	0.57	0.53	0.59	0.55	0.56	0.44	0.56	0.56	0.56	0.60	0.64	0.67
CVaR, $\beta = 0.05$	-17.69	-22.98	-42.21	-37.72	-27.28	-40.01	-34.65	-32.22	-21.84	-43.51	-20.06	-32.22	-30.09	-46.36	-31.92
Skewness	-0.25	-0.70	-0.69	-0.73	-0.37	-0.83	-0.33	-0.28	0.65	0.12	-0.01	0.00	-0.76	-0.47	-0.85
Kurtosis	3.75	4.83	7.46	8.25	6.00	8.64	6.88	2.35	3.59	3.95	3.27	2.43	3.35	3.44	3.62
Break-even transaction costs															
USD	5.63	4.67	-3.18	0.40	3.29	-2.01	0.68								
GBP	-6.43	-1.74	-15.66	-7.92	-4.07	-14.34	-9.00								
JPY	11.57	7.82	2.96	4.50	6.92	4.07	5.44								
EW	16.27	6.72	-15.48	-0.44	4.83	-10.70	-0.11								
Break-even transaction costs (RW)															
USD	8.50	6.19	-0.22	2.38	5.04	0.93	2.98								
GBP	4.53	4.08	-4.32	-0.36	2.62	-3.13	-0.21								
JPY	12.65	8.40	4.07	5.24	7.57	5.17	6.31								
EW	15.17	8.36	1.17	4.07	7.28	3.02	5.33								
Realized return															
Last 5 years	0.48	0.73	-1.16	-0.20	0.17	-0.94	-0.39	0.47	-0.31	-0.87	0.09	2.11	2.12	-3.71	0.43
Last 3 years	0.94	0.89	-1.33	0.13	0.30	-0.66	0.26	-3.03	2.84	-3.77	-1.05	3.23	3.61	-2.55	1.72
Last year	3.45	5.46	1.08	4.54	3.29	3.98	4.39	-8.87	10.63	-1.17	0.23	11.81	6.69	-4.49	4.73
Mean allocation															
USD	33.93	18.66	31.96	37.54	28.68	33.34	37.44	100	0	0	33.33	100	0	0	33.33
GBP	51.18	56.57	41.24	42.39	52.68	42.99	43.32	0	100	0	33.33	0	100	0	33.33
JPY	14.88	24.77	26.80	20.07	18.64	23.67	19.24	0	0	100	33.33	0	0	100	33.33

Table 8: *Optimal currency portfolios: Out-of-sample evaluation and comparison with benchmark portfolios (TS2, h=6).*

The table reports annual statistics of a monthly reallocated optimal currency portfolio and mean optimal weights, based on an optimization period of 36 months (rolling window), trading strategy 2 and a six-months forecast horizon. The evaluation period covers January 2008 to January 2016. Statistics are calculated on the basis of monthly returns and then annualized assuming discrete compounding. The same statistics are reported for the benchmark portfolios based on composite forecasts (i.e., the single assets of which the portfolios are constructed and the equally weighted portfolio) and for the benchmark portfolios based on the random walk. The sub-indices show the results of the bootstrap test. Their values indicate how many optimal portfolios outperform (in terms of the respective performance measure) that specific benchmark portfolio. If no sub-index is present, the benchmark portfolio is not outperformed by any of the optimal portfolios. If there is only one sub-index, its value indicates the number of optimal portfolios outperforming the benchmark portfolio at the 10% significance level. In the case of two sub-indices, the first one indicates the number of optimal portfolios outperforming the benchmark portfolio at the 5% significance level and the second one at the 10% significance level. Returns, weights and transaction costs are given in per cent.

	MV	CVaR, β	linear	LLA, λ		QLA, λ		USD	GBP	JPY	EW	USD	GBP	JPY	EW
		0.05		1.25	5.00	1.25	5.00					RW	RW	RW	RW
Performance measures															
Mean	-2.62	-2.38	-2.89	-2.75	-2.81	-2.72	-2.64	-2.02	-2.31	$-5.94_{2,7}$	$-3.42_{1,1}$	-0.94	-3.53	-1.13	-1.87
Omega	0.36	0.46	0.52	0.47	0.42	0.51	0.48	0.63	0.55	$0.31_{1,2}$	$0.26_{7,7}$	0.81	0.38	0.82	0.39
Sharpe ratio	-0.40	-0.31	-0.27	-0.29	-0.33	-0.27	-0.29	-0.19	-0.25	-0.45	-0.55	-0.09	-0.40	-0.08	-0.35
Sortino ratio	-0.42	-0.36	-0.32	-0.34	-0.37	-0.32	-0.34	-0.24	-0.29	-0.45	-0.53	-0.12	-0.42	-0.10	-0.38
Additional descriptive statistics															
Median	-2.03	-2.76	-3.08	-2.32	-1.93	-2.80	-2.40	-3.15	-2.90	-5.09	-3.74	-0.11	-3.78	-0.08	-2.52
Volatility	6.62	7.66	10.59	9.35	8.44	9.93	9.04	10.56	9.31	13.25	6.24	10.71	8.92	14.49	5.27
Down. vol.	6.21	6.60	9.04	8.15	7.56	8.44	7.88	8.45	7.96	13.25	6.45	8.19	8.47	11.52	4.89
Down. vol. ratio	0.65	0.59	0.60	0.61	0.62	0.59	0.61	0.56	0.60	0.70	0.69	0.54	0.66	0.57	0.65
CVaR, $\beta = 0.05$	-16.93	-17.27	-20.09	-20.90	-19.36	-19.84	-19.56	-19.71	-21.17	-33.64	-16.84	-19.93	-22.01	-33.64	-16.70
Skewness	0.07	0.33	0.27	0.13	0.14	0.28	0.14	0.21	-0.06	-0.22	0.22	-0.03	-0.13	-0.49	-0.48
Kurtosis	3.09	2.81	2.29	2.69	2.85	2.52	2.66	2.13	2.98	2.54	3.23	2.01	2.88	2.74	4.62
Break-even transaction costs															
USD	-0.73	-0.20	-1.08	-1.19	-1.19	-0.88	-0.86								
GBP	-0.12	0.17	-0.71	-0.69	-0.67	-0.52	-0.43								
JPY	2.18	1.60	0.68	1.22	1.27	0.86	1.20								
EW	7.42	2.07	0.19	1.36	1.55	0.56	1.25								
Break-even transaction costs (RW)															
USD	-6.17	-3.57	-4.36	-5.72	-5.79	-4.15	-4.71								
GBP	1.49	1.17	0.26	0.65	0.69	0.45	0.71								
JPY	-1.61	-0.75	-1.61	-1.93	-1.93	-1.41	-1.48								
EW	-2.67	-5.51	-9.75	-4.14	-4.00	-9.24	-5.16								
Realized return															
Last 5 years	-1.25	-0.58	-1.59	-1.24	-1.29	-1.29	-0.98	-0.22	-1.25	-7.45	-2.57	-3.09	-0.13	-6.49	-2.74
Last 3 years	-2.94	-3.01	-2.26	-2.37	-2.79	-2.14	-2.02	-3.88	-1.33	-11.57	-5.11	-5.31	1.48	-12.35	-4.88
Last year	-3.06	-4.53	-5.26	-5.15	-5.18	-4.89	-4.52	-9.88	-0.25	0.04	-3.07	-15.45	6.69	-4.57	-4.33
Mean allocation															
USD	35.74	61.37	59.79	49.81	48.05	62.09	55.89	100	0	0	33.33	100	0	0	33.33
GBP	41.54	24.93	29.90	41.34	42.16	29.91	37.08	0	100	0	33.33	0	100	0	33.33
JPY	22.72	13.70	10.31	8.85	9.79	8.00	7.02	0	0	100	33.33	0	0	100	33.33

Table 9: *Optimal currency portfolios: Out-of-sample evaluation and comparison with benchmark portfolios (TS1, h=12).*

The table reports annual statistics of a monthly reallocated optimal currency portfolio and mean optimal weights, based on an optimization period of 36 months (rolling window), trading strategy 1 and a 12-months forecast horizon. The evaluation period covers January 2008 to January 2016. Statistics are calculated on the basis of monthly returns and then annualized assuming discrete compounding. The same statistics are reported for the benchmark portfolios based on composite forecasts (i.e., the single assets of which the portfolios are constructed and the equally weighted portfolio) and for the benchmark portfolios based on the random walk. The sub-indices show the results of the bootstrap test. Their values indicate how many optimal portfolios outperform (in terms of the respective performance measure) that specific benchmark portfolio. If no sub-index is present, the benchmark portfolio is not outperformed by any of the optimal portfolios. If there is only one sub-index, its value indicates the number of optimal portfolios outperforming the benchmark portfolio at the 10% significance level. In the case of two sub-indices, the first one indicates the number of optimal portfolios outperforming the benchmark portfolio at the 5% significance level and the second one at the 10% significance level. Returns, weights and transaction costs are given in per cent.

	MV	CVaR, β	linear	LLA, λ		QLA, λ		USD	GBP	JPY	EW	USD	GBP	JPY	EW
		0.05		1.25	5.00	1.25	5.00					RW	RW	RW	RW
Performance measures															
Mean	-3.49	-3.53	-4.89	-4.10	-3.72	-4.10	-3.84	-1.60	-3.95	$-6.76_{3,6}$	-4.10	-1.91	-1.82	-0.82	-1.52
Omega	0.21	0.30	0.33	0.31	0.31	0.34	0.33	0.69	0.31	0.24	$0.17_{6,7}$	0.64	0.61	0.86	0.62
Sharpe ratio	-0.59	-0.50	-0.47	-0.47	-0.45	-0.43	-0.45	-0.15	-0.48	-0.55	-0.73	-0.19	-0.20	-0.06	-0.20
Sortino ratio	-0.55	-0.51	-0.48	-0.49	-0.48	-0.46	-0.47	-0.20	-0.48	-0.51	-0.63	-0.24	-0.24	-0.09	-0.24
Additional descriptive statistics															
Median	-3.27	-4.52	-5.60	-4.34	-3.00	-5.11	-4.19	-1.68	-5.23	-5.64	-4.81	-4.10	-2.06	-2.51	-0.88
Volatility	5.90	7.11	10.50	8.73	8.21	9.50	8.59	10.33	8.23	12.26	5.64	10.28	8.96	13.99	7.45
Down. vol.	6.36	6.99	10.21	8.45	7.80	8.98	8.17	8.12	8.22	13.18	6.56	7.85	7.64	9.40	6.42
Down. vol. ratio	0.72	0.65	0.66	0.65	0.64	0.64	0.64	0.56	0.68	0.74	0.74	0.54	0.61	0.48	0.62
CVaR, $\beta = 0.05$	-16.08	-17.01	-23.69	-19.82	-19.06	-21.87	-19.46	-19.53	-20.36	-33.70	-16.13	-18.33	-20.36	-24.30	-17.53
Skewness	0.08	0.44	0.36	0.45	0.49	0.39	0.45	0.12	0.02	-0.32	0.27	0.47	-0.35	0.66	-0.34
Kurtosis	3.34	3.07	2.66	3.17	3.52	2.86	3.21	2.13	3.01	2.58	3.39	2.39	2.63	3.21	2.10
Break-even transaction costs															
USD	-6.99	-4.78	-5.12	-6.69	-6.78	-5.61	-7.16								
GBP	0.90	0.47	-0.38	-0.11	0.26	-0.12	0.12								
JPY	1.81	1.07	0.17	0.65	1.08	0.51	0.97								
EW	-5.27	1.85	-1.38	-4.74	-6.08	-0.85	-0.94								
Break-even transaction costs (RW)															
USD	-4.12	-2.88	-3.39	-4.30	-4.22	-3.61	-4.51								
GBP	-5.84	-4.02	-4.43	-5.73	-5.76	-4.81	-6.10								
JPY	-10.52	-7.14	-7.24	-9.63	-9.93	-8.06	-10.42								
EW	-15.27	-23.61	-19.28	-90.84	-263.46	-30.31	-5160.70								
Realized return															
Last 5 years	-1.40	-1.67	-2.51	-1.71	-1.14	-1.89	-1.58	0.23	-2.58	-7.58	-2.91	0.12	1.65	2.72	1.85
Last 3 years	-1.26	-0.88	-0.19	-0.60	-0.23	-0.18	-0.25	-0.19	-1.87	-11.67	-4.11	3.57	3.86	6.74	5.21
Last year	-2.01	-3.22	-7.20	-6.84	-4.69	-7.20	-6.60	-7.20	-0.43	0.07	-2.14	11.77	9.43	-4.60	5.69
Mean allocation															
USD	37.22	47.13	45.36	53.71	51.75	53.47	55.10	100	0	0	33.33	100	0	0	33.33
GBP	47.43	38.59	25.77	30.96	35.23	25.67	29.04	0	100	0	33.33	0	100	0	33.33
JPY	15.35	14.28	28.87	15.33	13.02	20.86	15.86	0	0	100	33.33	0	0	100	33.33

Table 10: *Optimal currency portfolios: Out-of-sample evaluation and comparison with benchmark portfolios (TS2, h=12).*

The table reports annual statistics of a monthly reallocated optimal currency portfolio and mean optimal weights, based on an optimization period of 36 months (rolling window), trading strategy 2 and a 12-months forecast horizon. The evaluation period covers January 2008 to January 2016. Statistics are calculated on the basis of monthly returns and then annualized assuming discrete compounding. The same statistics are reported for the benchmark portfolios based on composite forecasts (i.e., the single assets of which the portfolios are constructed and the equally weighted portfolio) and for the benchmark portfolios based on the random walk. The sub-indices show the results of the bootstrap test. Their values indicate how many optimal portfolios outperform (in terms of the respective performance measure) that specific benchmark portfolio. If no sub-index is present, the benchmark portfolio is not outperformed by any of the optimal portfolios. If there is only one sub-index, its value indicates the number of optimal portfolios outperforming the benchmark portfolio at the 10% significance level. In the case of two sub-indices, the first one indicates the number of optimal portfolios outperforming the benchmark portfolio at the 5% significance level and the second one at the 10% significance level. Returns, weights and transaction costs are given in per cent.