

```
In [3]: %config InlineBackend.figure_format = 'retina'
import pandas as pd
import os
```

Benchmarking the System Performance

```
In [24]: run_id = "SP900_Predictors_Horizon40"

In [24]: os.mkdir(run_id)

In [24]: dir_ = "." + run_id + "/"

This Jupyter notebook serves to benchmark the performance of the prototype system.
```

Loading and importing the system

```
In [245]: from ..tools.dataloader.py
from ..system.activate.py
```

Loading and importing financial data to forecast and to benchmark the system on

```
In [246]: predict = DataLoader({"ISPC", "2018-02-01", "2018-05-01"})
predict = predict.get_adjclose()

In [247]: predict_req, real = data_req(predict, 20, 40) # dividing data into predictor input and real data
```

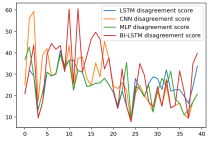
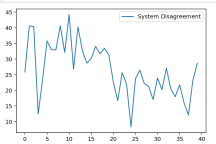
Individual predictor forecasts

```
In [248]: Individual_predictors_forecasts = Individual_predictors_untrained_SP900_40_4(predict_req, 40)

WARNING:tensorflow:ll out of the last 11 calls to <function Model.make_predict_function.<locals>.predict_function at 0x000001C0E32AC60> triggered tf.function retracing. Tracing is expensive and the excessive number of tracings could b
e due to (1) creating @tf.function repeatedly in a loop, (2) passing tensors with different shapes, (3) passing Python objects instead of tensors. For (1), please define your @tf.function outside of the loop. For (2), @tf.function has
experimental_relax_shapes=True option that relaxes argument shapes that can avoid unnecessary retracing. For (3), please refer to https://www.tensorflow.org/tutorials/customization/performance/python_or_tensor_args and https://www.tens
orflow.org/api_docs/python/tf.function for more details.
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WARNING:tensorflow:ll out of the last 11 calls to <function Model.make_predict_function.<locals>.predict_function at 0x000001C0E32AC60> triggered tf.function retracing. Tracing is expensive and the excessive number of tracings could b
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experimental_relax_shapes=True option that relaxes argument shapes that can avoid unnecessary retracing. For (3), please refer to https://www.tensorflow.org/tutorials/customization/performance/python_or_tensor_args and https://www.tens
orflow.org/api_docs/python/tf.function for more details.
```

System disagreement between individual predictor forecasts

system_disagreement(Individual_predictors_forecasts)



Building consensus forecast values

```
In [248]: consensus_forecasts = consensus(Individual_predictors_forecasts, real)

In [249]: all_forecasts = combined_frame(Individual_predictors_forecasts, consensus_forecasts, real)

In [250]: summary = all_stats_frame(all_forecasts, Individual_predictors_forecasts) # combining individual predictor forecasts, consensus forecasts and disagreement scores
summary
```

	Average	NoMemory	Memory	Focus	Anchor	Correcting	Correcting Memory	Real Value	LSTM	CNN	MLP	Bi-LSTM	System Disagreement	LSTM disagreement score	CNN disagreement score	MLP disagreement score	Bi-LSTM disagreement score
Date																	
2018-02-02	2755.539124	2755.539124	2755.539124	2783.257690	2755.539124	2755.539124	2691.250000	2738.724211	2760.656250	2792.392578	2760.383545	25.858551	20.848938	24.882874	36.853455	20.848938	25.885551
2018-03-05	2773.019531	2774.871599	2736.945565	2682.990234	2734.006688	2675.031129	2707.026330	2720.839941	2771.204666	2682.990234	2781.676054	2760.208740	40.630168	31.920166	56.029297	42.651123	21.920166
2018-05-06	2751.476424	2750.634488	2750.237759	2752.266602	2749.109105	2731.369608	2724.004159	2728.120117	2752.266602	2692.222656	2766.308350	2795.108887	40.373555	29.231995	59.231967	43.632263	40.373555
2018-07-07	2746.247996	2745.788285	2745.608461	2744.381348	2775.282041	2723.313179	2720.079652	2726.800049	2744.381348	2729.019116	2759.778018	2751.878662	12.451202	9.550554	17.234070	13.470032	9.550554
2018-08-08	2746.306580	2743.943021	2746.671877	2709.475586	2750.597501	2728.798323	2723.384050	2738.969971	2753.419189	2709.475586	2769.841064	2760.490479	23.520966	16.859192	38.809594	21.534485	16.859192
2018-09-09	2742.942871	2743.880986	2741.589054	2742.987061	2748.968590	2734.589418	2721.595814	2786.570008	2722.987061	2766.521700	2783.251953	25.784973	30.946553	41.937500	30.946553	39.308682	35.784973
2018-10-12	2756.105530	2763.656171	2755.238895	2800.345258	2764.840744	2769.956519	2743.027047	2783.000200	2722.724802	2766.711914	2770.051025	2800.345258	32.964142	29.102112	39.361616	29.102112	44.258728
2018-10-13	2756.411011	2762.027129	2756.299910	2778.712501	2761.364654	2763.328971	2748.325643	2765.310059	2776.178751	2766.708496	2774.781250	2797.862432	32.938049	30.239136	29.970825	29.970825	44.258728
2018-10-14	2751.367000	2754.917775	2751.477102	2786.236023	2755.763710	2760.163289	2745.112325	2749.479980	2710.479807	2773.984131	2786.236023	2794.727319	40.614049	40.891113	39.137451	43.396191	40.614049
2018-10-15	2742.506287	2742.045895	2742.016137	2731.770508	2737.770208	2740.739221	2736.776670	2747.330078	2708.827893	2713.770508	2747.979004	2772.448244	32.141571	33.788784	31.207336	32.472717	31.207336
2018-10-16	2759.309326	2761.262533	2759.654099	2819.684614	2771.720132	2764.119393	2754.403208	2752.010010	2729.621719	2755.840178	2772.037354	2819.684614	44.263238	36.551758	43.466309	36.551758	40.373555
2018-10-19	2746.609985	2744.324693	2746.444079	2760.880222	2732.757134	2749.646040	2741.737198	2732.919922	2727.724802	2766.711914	2770.051025	2800.345258	26.781738	26.472656	22.472656	25.842456	26.472656
2018-10-20	2759.831543	2753.378180	2759.220998	2773.973389	2765.603163	2755.942670	2752.504857	2766.939941	2733.973389	2722.464844	2762.473877	2820.414062	40.293518	31.612427	37.366699	31.612427	40.293518
2018-10-21	2754.898621	2747.164321	2753.975743	2763.820551	2736.977244	2752.234305	2745.154642	2731.929932	2731.158203	2785.929443	2785.929443	2751.547885	32.716095	30.893494	38.046570	31.038023	30.893494
2018-10-22	2758.152527	2752.258338	2756.808094	2773.318848	2753.032382	2751.212132	2746.234741	2764.889941	2737.574463	2763.318848	2768.053223	2796.663574	28.891177	24.205872	27.833679	24.205872	38.511047
2018-10-23	2768.720842	2762.524595	2767.255853	2765.261826	2743.814643	2761.263216	2745.316793	2588.260010	2744.255859	2743.773928	2771.710449	2815.142314	30.194777	24.750750	24.467102	24.750750	30.194777
2018-10-24	2758.558167	2756.904772	2757.072053	2752.409912	2728.118009	2578.742055	2730.701079	2688.550049	2742.286377	2723.409912	2760.433094	2808.102783	34.028229	25.710022	35.148254	25.710022	49.544617

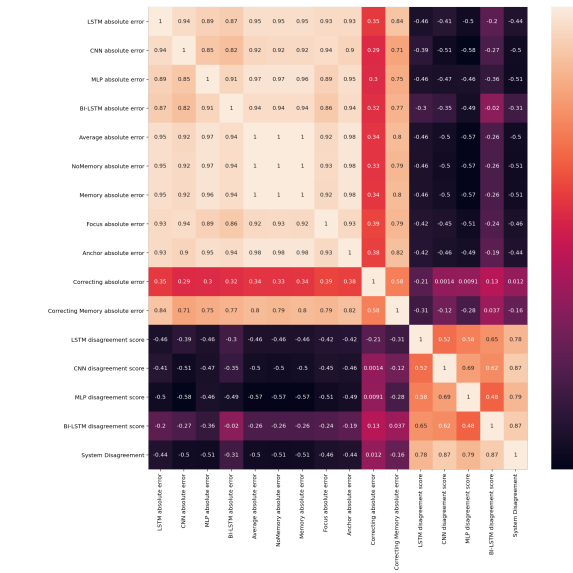
	Average	NoMemory	Memory	Focus	Anchor	Correcting	Correcting Memory	Real Value	LSTM	CNN	MLP	Bi-LSTM	System Disagreement	LSTM disagreement score	CNN disagreement score	MLP disagreement score	Bi-LSTM disagreement score
Date																	
2018-02-02	2766.303406	2763.232046	2764.724688	2745.548986	2745.780397	2666.039195	2734.359609	2812.620117	2743.255615	2737.545888	2771.895020	2812.517090	31.694122	25.902649	28.717507	25.902649	46.213684
2018-03-05	2765.837158	2764.112899	2764.642575	2725.542969	2735.882760	2612.200809	2727.478641	2605.000000	2755.034912	2720.542969	2769.589580	2798.201172	33.438660	28.048218	45.294189	28.048218	32.364014
2018-03-09	2767.886353	2766.154559	2766.462837	2730.559814	2739.208623	2606.967906	2723.938366	2640.870117	2755.091797	2730.559814	2780.463667	2805.429932	31.247031	25.060747	37.326538	25.060747	37.545379
2018-04-02	2764.823181	2763.335863	2763.708913	2740.318895	2734.497290	2628.013073	2716.514153	2581.879883	2746.336182	2740.318895	2784.787354	2787.852295	22.632172	21.496643	24.506287	21.496643	23.029114
2018-04-03	2762.375916	2761.806780	2761.718230	2739.153320	2725.962850	2654.648566	2708.060847	2614.449951	2757.719277	2739.153320	2777.961426	2774.689189	16.671722	13.939392	23.222995	15.885101	13.939392
2018-04-04	2762.912842	2762.197838	2761.678600	2736.989717	2741.688760	2647.931237	2704.434803	2644.889941	2744.683350	2736.989717	2774.602051	2795.400510	25.627808	22.091309	25.931325	22.091309	32.483480
2018-04-05	2766.755042	2765.087653	2765.300810	2743.322510	2744.340062	2647.518997	2704.825575	2662.840088	2758.353516	2743.322510	2801.249512	2780.098633	21.940765	14.918300	22.433333	35.493489	14.918300
2018-04-06	2765.980489	2765.576741	2765.004722	2739.206543	2735.400056	2661.127995	2703.417438	2604.469971	2757.256194	2758.206543	2774.965332	2772.439896	8.301880	8.724385	7.749146	8.984863	7.749146
2018-04-09	2777.209534	2776.898827	2776.005643	2749.228448	2755.151093	2615.006613	2710.465929	2615.199512	2749.228448	2762.810303	2801.521438	2795.271461	23.684427	27.880286	21.189978	24.113904	21.189978
2018-04-10	2776.632572	2775.685347	2775.377160	2755.345703	2749.624642	2616.510777	2706.253016	2656.870117	2755.345703	2751.814209	2787.738084	2811.600304	26.471069	23.045776	24.811523	23.045776	34.981201
2018-04-11	2775.799927	2774.380395	2774.729961	2755.246069	2751.064752	2656.112147	2703.718218	2642.189941	2756.955532	2755.246069	2786.041992	2805.477783	22.168274	19.459961	20.075317	19.459961	29.677856
2018-04-12	2762.561157	2771.838637	2771.779062	2744.090576	2747.087332	2659.154968	2698.402554	2663.989990	2746.847168	2764.090576	2759.522446	2781.754639	21.224122	25.719896	17.052285	24.991089	17.052285
2018-04-13	2771.171509	2770.339865	2770.313659	2742.457564	2747.763762	2664.688445	2696.027624	2656.300049	2742.457564	2775.314463	2780.945115	2785.970703	17.020915	12.854045	12.854045	14.799194	12.854045
2018-04-16	2773.428101	2772.495152	2772.323233	2745.409238	2754.914247	2658.452051	2696.853919	2677.840088	2745.409238	2757.638916	2793.078857	2797.525191	23.951050	27.958862	21.874023	21.874023	24.097290
2018-04-17	2772.624084	2769.610107	2769.089415	2747.843262	2753.273697	2675.180211	2693.650585	2706.388993	2747.843262	2743.498291	2788.653564	2772.501221	20.179230	22.780283	14.933308	28.029480	14.933308
2018-04-18	2777.954651	2776.008896	2776.667733	2745.966054	2766.994466	2713.538074	2701.030706	2708.639893	2745.966054	2740.031023	2799.317327	2805.501709	27.114240	31.988856	24.450517	24.450517	27.547058
2018-04-19	2770.778442	2769.580999	2770.240913	2746.670898	2757.580075	2701.753340	2694.391646	2683.129883	2748.670898	2767.785645	2802.109131	2764.548096	20.440321	22.107544	14.168945	31.250888	14.168945
2018-04-20	2776.990845	2777.895840	2778.171193	2756.300293	2759.839880	2701.155803	2702.306221	2670.139893	2756.300293	2770.852539	2797.256483	2791.546554	17.483654	22.690552	15.414629	18.274048	15.414629
2018-04-23	2778.102895	2788.554276	2788.346892	2766.361328	2773.152057	2789.866600	2711.246096	2702.200309	2766.361328	2790.325684	2779.052041	2800.625688	25.755920	22.741577	16.376221	16.376221	31.256663
2018-04-24	2782.249308	2780.490173	2782.600640	2767.412393	2775.486740	2664.723460	2704.482736	2634.580059	2763.452393	2783.235596	2781.010254	2805.258482	15.970581	19.796875	11.017944	11.017944	22.049517
2018-04-25	2784.254100	2784.093999	2783.769963	2767.927197	2772.486105	2655.506400	2704.338261	2639.399902	2787.891113	2781.871827	2797.453169	2789.659480	12.000544	16.396307	13.190219	13.190219	3.939780
2018-04-26	2784.867737	2784.604302	2784.025536	2768.819092	2764.507146	2639.983235	2702.541521	2666.939941	2780.819092	2784.134277	2774.843994	2789.873584	23.231720	24.048445	17.086194	17.086194	34.805847
2018-04-27	2780.899292	2779.350408	2779.651991	2747.212158	2762.380889	2663.114446	2697.742940	2669.909912	2747.212158	2773.296387	2782.511719	2800.576904	28.683696	33.687134	20.645020	20.645020	39.678712

Date	LSTM absolute error	CNN absolute error	MLP absolute error	Bi-LSTM absolute error	Average absolute error	NoMemory absolute error	Memory absolute error	Focus absolute error	Anchor absolute error	Correcting absolute error	Correcting Memory absolute error	LSTM disagreement score	CNN disagreement score	MLP disagreement score	Bi-LSTM disagreement score	System Disagreement
2018-04-12	82.857178	100.100586	133.562256	117.764648	108.571167	107.848646	107.807072	100.100586	83.097342	24.835022	34.502564	25.713989	17.092285	24.991089	17.092285	21.222412
2018-04-13	86.157715	119.014404	124.643066	129.670654	114.871460	114.039816	114.213610	86.157715	91.463713	6.385396	39.327575	28.173745	12.285400	12.285400	14.799194	17.520935
2018-04-16	67.629150	79.78828	115.238770	119.685303	95.588013	94.655064	94.482236	67.629150	77.081339	19.388037	19.013831	27.958862	21.874023	21.874023	24.097290	23.951050
2018-04-17	41.453369	57.108398	92.263672	66.115328	64.234192	63.061215	63.599523	41.453369	46.883805	31.200681	12.784207	22.790823	14.953308	28.029480	14.953308	20.179320
2018-04-18	37.326172	52.393311	96.007734	96.861816	69.3714758	67.369004	68.027840	37.326172	58.354574	4.898181	7.609187	31.988566	24.455017	24.455017	27.547058	27.111420
2018-04-19	55.541016	74.655762	108.978248	71.418213	77.648560	76.139116	77.115131	55.541016	64.456193	8.623457	1.267164	22.107544	14.168945	31.330688	14.168945	20.440311
2018-04-20	86.160400	100.712646	127.125000	121.405762	108.850952	107.755948	108.031301	86.160400	89.699887	31.015910	32.166329	22.890552	15.414429	18.274048	15.414429	17.948364
2018-04-23	96.071289	120.035645	108.802002	150.342829	118.812866	118.262437	118.056653	96.071289	102.862108	9.595661	40.976527	22.741577	16.376221	16.376221	31.529663	21.755920
2018-04-24	128.892334	148.875537	146.450195	170.738770	148.689329	147.870116	148.045811	128.892334	122.906681	30.163401	69.932677	19.796785	11.017944	11.017944	22.049561	15.970581
2018-04-25	128.491211	142.417725	158.053467	150.454590	144.854248	144.620033	144.370061	128.491211	113.496198	3.845262	64.233919	16.363037	9.399780	13.199219	9.399780	12.090454
2018-04-26	93.879150	117.194336	107.904053	152.738643	117.927795	117.643681	117.083394	93.879150	95.567205	26.956707	35.601579	24.048845	17.036194	17.036194	24.805847	23.231720
2018-04-27	77.302246	103.886475	112.601807	150.666992	110.989380	109.448496	109.742079	77.302246	92.470977	6.795466	27.833028	33.687134	20.645020	20.645020	39.677612	28.663696

```
In [295]: prediction_error_to_csv(dir_ + run_id + "_prediction_errors.csv")
```

Correlation matrix of individual predictor and consensus forecast absolute errors

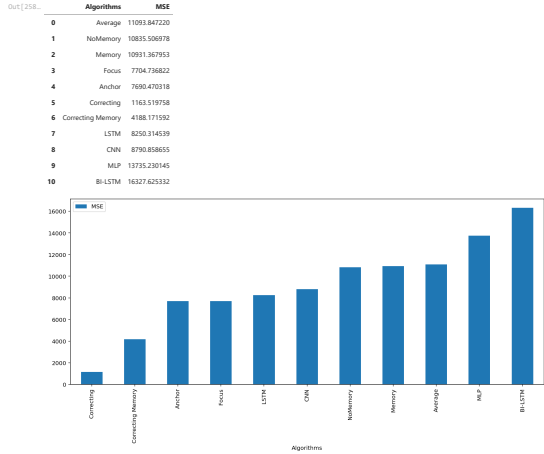
	correlation_ = correlation(prediction_error, True)															
	correlation_															
Out[256]	LSTM absolute error	CNN absolute error	MLP absolute error	Bi-LSTM absolute error	Average absolute error	NoMemory absolute error	Memory absolute error	Focus absolute error	Anchor absolute error	Correcting absolute error	Correcting Memory absolute error	LSTM disagreement score	CNN disagreement score	MLP disagreement score	Bi-LSTM disagreement score	System Disagreement
LSTM absolute error	1.000000	0.938143	0.893560	0.871239	0.945079	0.947334	0.946961	0.930212	0.926436	0.349626	0.838740	-0.458200	-0.411759	-0.503146	-0.199601	-0.437851
CNN absolute error	0.938143	1.000000	0.851831	0.820643	0.918440	0.920320	0.920802	0.940430	0.903716	0.288219	0.712769	-0.390117	-0.510245	-0.575052	-0.266890	-0.502092
MLP absolute error	0.893560	0.851831	1.000000	0.910404	0.966244	0.967156	0.964705	0.895285	0.949946	0.298213	0.747728	-0.456333	-0.458970	-0.339626	-0.339626	-0.510324
Bi-LSTM absolute error	0.871239	0.820643	0.910404	1.000000	0.943656	0.941986	0.941986	0.936931	0.931648	0.767589	-0.295429	-0.331807	-0.482940	-0.502471	-0.308639	-0.502471
Average absolute error	0.945079	0.918440	0.966244	0.943656	1.000000	0.999150	0.999915	0.922505	0.980315	0.335017	0.797399	-0.447755	-0.496563	-0.565058	-0.251490	-0.504482
NoMemory absolute error	0.947334	0.920320	0.967156	0.941986	0.999150	1.000000	0.999915	0.930748	0.980305	0.331159	0.788975	-0.457382	-0.501781	-0.565810	-0.263281	-0.509520
Memory absolute error	0.946961	0.920802	0.964705	0.941986	0.999915	0.999520	1.000000	0.924143	0.980532	0.335671	0.798674	-0.457657	-0.499894	-0.565367	-0.256077	-0.505967
Focus absolute error	0.930212	0.940430	0.892385	0.922505	0.936748	0.924143	0.980532	1.000000	0.925501	0.387724	0.787059	-0.422169	-0.448904	-0.511422	-0.243318	-0.462385
Anchor absolute error	0.926436	0.903716	0.949946	0.936931	0.980315	0.980305	0.980532	0.925501	1.000000	0.376127	0.819015	-0.416754	-0.463994	-0.487798	-0.194304	-0.441988
Correcting absolute error	0.349626	0.288219	0.298213	0.316448	0.335017	0.331159	0.335671	0.387724	0.376127	1.000000	0.579001	-0.210448	0.000413	0.000071	0.134291	0.012454
Correcting Memory absolute error	0.838740	0.712769	0.747728	0.767589	0.797399	0.788975	0.798674	0.787059	0.819015	0.579001	1.000000	-0.311128	-0.124154	-0.273288	0.036586	-0.158063
LSTM disagreement score	-0.458200	-0.390117	-0.456333	-0.295429	-0.457755	-0.457382	-0.457657	-0.422169	-0.416754	-0.210448	-0.311128	1.000000	0.516970	0.577658	0.646000	0.784028
CNN disagreement score	-0.411759	-0.510245	-0.456593	-0.351807	-0.496563	-0.501781	-0.499894	-0.448904	-0.463994	0.000413	-0.124154	0.516970	1.000000	0.687452	0.620420	0.869286
MLP disagreement score	-0.503146	-0.575052	-0.458970	-0.492940	-0.565058	-0.565810	-0.565567	-0.511422	-0.487798	0.000071	-0.273288	0.577658	0.687452	1.000000	0.478494	0.787211
Bi-LSTM disagreement score	-0.199601	-0.266890	-0.339626	-0.308639	-0.404482	-0.404482	-0.404482	-0.308639	-0.441988	0.012454	-0.036586	0.646000	0.620420	0.478494	1.000000	0.865417
System Disagreement	-0.437851	-0.502092	-0.510324	-0.508639	-0.504482	-0.509520	-0.505967	-0.462385	-0.441988	0.012454	-0.158063	0.784028	0.869286	0.787211	0.865417	1.000000



```
In [297]: correlation_to_csv(dir_ + run_id + "_error_correlation.csv")
```

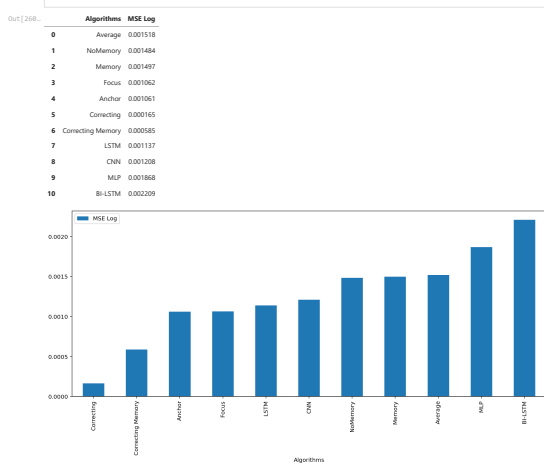
MSE, MSE log and MAE scores

```
In [298]: mse = mse_score(all_forecasts, True)
mse
```



```
In [299]: mse_to_csv(dir_ + run_id + "_mse_score.csv")
```

```
In [300]: mse_log = mse_log_score(all_forecasts, True)
mse_log
```

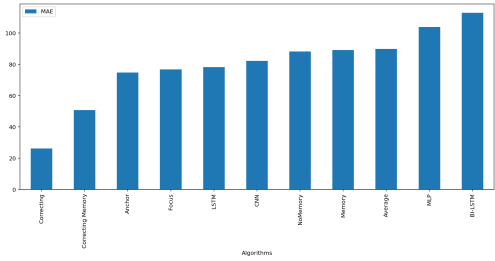


```
In [301]: mse_log_to_csv(dir_ + run_id + "_mse_log_score.csv")
```

```
In [302]: mae = mae_score(all_forecasts, True)
mae
```



Algorithms	MAE
0	Average 89.856659
1	NoMemory 88.161280
2	Memory 89.130373
3	Focus 76.767500
4	Anchor 74.736821
5	Correcting 26.257716
6	Correcting Memory 50.696191
7	LSTM 78.147498
8	CNN 82.169562
9	MLP 103.751843
10	Bi-LSTM 112.829205



```
In [263]: rmse_to_csv(df_rm = rmse_id + "_RMSE_allconv.csv")
```

Performance plotting of all forecasting algorithms

```
In [264]: plot_performance(all_forecasts)
```

