TABLE 1.1: The long-term forecasting task. We compare extensive competitive models under different prediction lengths. Avg is averaged from all four forecasting lengths {96, 192, 336, 720}.

Methods		TCDNet		TimeMixer		U-Mixer		UnetTS		iTrans*		ModernTCN		Cross*		FED*		MTSMixer		Dlinear		Rlinear		SCINet		RMLP		TimesNet		LightTS		MICN	
Metric		MSE	MAE	MSE	MAE	MSE	MAE	MSE	MAE	MSE	MAE	MSE	MAE	MSE	MAE	MSE	MAE	MSE	MAE	MSE	MAE	MSE	MAE	MSE	MAE	MSE	MAE	MSE	MAE	MSE	MAE	MSE	MAE
ETTh1	96	**0.352**	**0.387**	**0.361**	**0.390**	0.370	0.390	0.370	0.406	0.377	0.395	0.368	0.394	0.386	0.429	0.376	0.415	0.372	0.395	0.375	0.399	0.360	0.391	0.375	0.406	0.390	0.410	0.384	0.402	0.424	0.432	0.396	0.427
	192	**0.387**	**0.405**	0.409	0.414	0.423	0.421	0.406	0.425	0.436	0.429	**0.405**	**0.413**	0.419	0.444	0.423	0.446	0.416	0.426	0.405	0.416	0.404	0.412	0.416	0.421	0.430	0.432	0.557	0.436	0.475	0.462	0.430	0.453
	336	**0.383**	**0.405**	0.430	0.429	0.470	0.442	0.402	0.425	0.471	0.447	**0.391**	**0.412**	0.440	0.461	0.444	0.462	0.455	0.449	0.439	0.443	0.420	0.423	0.504	0.495	0.441	0.441	0.491	0.469	0.518	0.521	0.433	0.458
	720	**0.439**	**0.455**	**0.445**	**0.460**	0.500	0.473	0.461	0.478	0.495	0.482	0.450	0.461	0.519	0.524	0.469	0.492	0.475	0.472	0.472	0.490	0.442	0.456	0.544	0.527	0.506	0.495	0.521	0.500	0.547	0.533	0.474	0.508
Avg		**0.390**	**0.413**	0.411	0.423	0.441	0.432	0.410	0.434	0.445	0.438	**0.404**	**0.420**	0.441	0.465	0.428	0.454	0.430	0.436	0.423	0.437	0.407	0.421	0.460	0.462	0.442	0.445	0.488	0.452	0.491	0.487	0.433	0.462
ETTh2	96	**0.230**	**0.314**	0.271	0.330	0.290	0.335	0.271	0.339	0.274	0.336	**0.263**	**0.332**	0.628	0.563	0.332	0.374	0.307	0.354	0.289	0.353	0.262	0.331	0.295	0.361	0.288	0.352	0.340	0.374	0.397	0.437	0.289	0.357
	192	**0.282**	**0.352**	**0.317**	**0.402**	0.366	0.386	0.330	0.381	0.384	0.401	0.320	0.374	0.703	0.624	0.407	0.446	0.374	0.399	0.383	0.418	0.320	0.374	0.349	0.383	0.343	0.387	0.402	0.414	0.520	0.504	0.409	0.438
	336	**0.325**	**0.383**	0.332	0.396	0.423	0.428	0.322	0.384	0.407	0.424	**0.313**	**0.376**	0.827	0.675	0.400	0.447	0.398	0.432	0.448	0.465	0.325	0.386	0.365	0.409	0.353	0.402	0.452	0.452	0.626	0.559	0.417	0.452
	720	**0.383**	**0.424**	**0.342**	**0.408**	0.446	0.445	0.404	0.442	0.418	0.439	0.392	0.433	1.181	0.840	0.412	0.469	0.463	0.465	0.605	0.551	0.372	0.421	0.475	0.488	0.410	0.440	0.462	0.468	0.863	0.672	0.426	0.473
Avg		**0.305**	**0.368**	**0.316**	**0.384**	0.381	0.399	0.332	0.387	0.371	0.400	0.322	0.379	0.835	0.676	0.388	0.434	0.386	0.413	0.431	0.447	0.320	0.378	0.371	0.410	0.349	0.395	0.414	0.427	0.602	0.543	0.385	0.430
ETTm1	96	**0.305**	**0.353**	**0.291**	**0.340**	0.317	0.349	0.301	0.353	0.331	0.366	0.292	0.346	0.316	0.373	0.326	0.390	0.314	0.358	0.299	0.343	0.301	0.342	0.325	0.372	0.298	0.345	0.338	0.375	0.374	0.400	0.314	0.360
	192	**0.331**	**0.363**	**0.327**	**0.365**	0.369	0.376	0.342	0.375	0.374	0.387	0.332	0.368	0.377	0.411	0.365	0.415	0.354	0.386	0.335	0.365	0.335	0.363	0.354	0.386	0.344	0.375	0.371	0.387	0.400	0.407	0.359	0.387
	336	**0.353**	**0.383**	0.360	0.381	0.395	0.393	0.376	0.399	0.411	0.412	0.365	0.391	0.431	0.442	0.382	0.425	0.384	0.405	0.369	0.386	0.370	0.383	0.394	0.415	0.390	0.410	0.410	0.411	0.438	0.438	0.410	0.411
	720	**0.394**	**0.408**	0.415	0.417	0.443	0.424	0.428	0.425	0.478	0.449	0.416	0.417	0.600	0.547	0.446	0.458	0.427	0.432	0.425	0.421	0.425	0.414	0.476	0.469	0.445	0.441	0.478	0.450	0.527	0.502	0.459	0.464
Avg		**0.346**	**0.377**	**0.348**	**0.376**	0.381	0.386	0.362	0.388	0.399	0.403	0.351	0.381	0.431	0.443	0.380	0.422	0.370	0.395	0.357	0.379	0.358	0.376	0.387	0.411	0.369	0.393	0.399	0.406	0.435	0.437	0.386	0.406
ETTm2	96	**0.161**	**0.248**	**0.164**	**0.254**	0.178	0.256	0.171	0.261	0.179	0.263	0.166	0.256	0.421	0.461	0.180	0.271	0.177	0.259	0.167	0.260	0.164	0.253	0.186	0.281	0.174	0.259	0.187	0.267	0.209	0.308	0.178	0.273
	192	**0.212**	**0.286**	0.223	0.295	0.243	0.301	0.229	0.299	0.249	0.308	**0.222**	**0.293**	0.503	0.519	0.252	0.318	0.241	0.303	0.224	0.303	0.219	0.290	0.277	0.356	0.236	0.303	0.249	0.309	0.311	0.382	0.245	0.316
	336	**0.260**	**0.324**	0.279	0.330	0.331	0.355	0.280	0.330	0.310	0.345	**0.272**	**0.324**	0.611	0.580	0.324	0.364	0.297	0.338	0.281	0.342	0.273	0.326	0.311	0.369	0.291	0.338	0.321	0.351	0.442	0.466	0.295	0.350
	720	**0.333**	**0.383**	0.359	0.383	0.434	0.413	0.362	0.389	0.406	0.400	**0.351**	**0.381**	0.996	0.750	0.410	0.420	0.396	0.398	0.397	0.421	0.366	0.385	0.403	0.412	0.371	0.391	0.497	0.403	0.675	0.587	0.389	0.412
Avg		**0.242**	**0.310**	0.256	0.316	0.297	0.331	0.261	0.320	0.286	0.329	**0.253**	**0.314**	0.633	0.578	0.292	0.343	0.278	0.325	0.267	0.332	0.256	0.314	0.294	0.355	0.268	0.323	0.314	0.333	0.409	0.436	0.277	0.338
ECL	96	**0.122**	**0.223**	0.129	0.224	0.151	0.240	0.133	0.231	0.145	0.235	0.129	0.226	0.187	0.283	0.186	0.302	0.141	0.243	0.153	0.237	0.140	0.235	0.171	0.256	0.129	0.224	0.168	0.272	0.207	0.307	0.159	0.267
	192	**0.143**	**0.243**	**0.140**	**0.220**	0.163	0.250	0.147	0.244	0.161	0.250	0.143	0.239	0.258	0.330	0.197	0.311	0.163	0.261	0.152	0.249	0.154	0.248	0.177	0.265	0.147	0.240	0.184	0.289	0.213	0.316	0.168	0.279
	336	**0.163**	**0.261**	0.166	0.255	0.179	0.264	0.166	0.264	0.173	0.266	**0.161**	**0.259**	0.323	0.369	0.213	0.328	0.176	0.277	0.169	0.267	0.171	0.264	0.197	0.285	0.164	0.257	0.198	0.300	0.230	0.333	0.196	0.308
	720	**0.184**	**0.271**	0.194	0.287	0.210	0.294	0.197	0.292	0.222	0.306	**0.191**	**0.286**	0.404	0.423	0.233	0.344	0.212	0.308	0.233	0.344	0.209	0.297	0.234	0.318	0.203	0.291	0.220	0.320	0.265	0.360	0.203	0.312
Avg		**0.153**	**0.250**	0.157	0.247	0.185	0.277	0.161	0.258	0.175	0.264	**0.156**	**0.253**	0.293	0.351	0.207	0.321	0.173	0.272	0.177	0.274	0.169	0.261	0.195	0.281	0.161	0.253	0.193	0.295	0.229	0.329	0.182	0.292
Traffic	96	**0.367**	**0.254**	**0.360**	**0.249**	0.451	0.280	0.386	0.266	0.384	0.263	0.368	0.253	0.512	0.290	0.576	0.359	0.462	0.332	0.410	0.282	0.496	0.375	0.613	0.395	0.430	0.327	0.593	0.321	0.615	0.391	0.508	0.301
	192	**0.380**	**0.261**	**0.379**	**0.256**	0.458	0.277	0.398	0.274	0.404	0.271	0.379	0.261	0.523	0.297	0.610	0.380	0.488	0.354	0.423	0.287	0.503	0.377	0.559	0.363	0.451	0.340	0.617	0.336	0.601	0.382	0.536	0.315
	336	**0.396**	**0.269**	**0.392**	**0.264**	0.477	0.278	0.417	0.284	0.415	0.276	0.397	0.270	0.530	0.300	0.608	0.375	0.498	0.360	0.436	0.296	0.517	0.382	0.555	0.358	0.470	0.351	0.629	0.336	0.613	0.386	0.525	0.310
	720	**0.436**	**0.292**	**0.432**	**0.286**	0.520	0.288	0.462	0.311	0.451	0.295	0.440	0.296	0.573	0.313	0.621	0.375	0.529	0.370	0.466	0.315	0.555	0.398	0.620	0.394	0.513	0.372	0.640	0.350	0.658	0.407	0.571	0.323
Avg		**0.395**	**0.269**	0.391	0.264	0.477	0.281	0.416	0.284	0.413	0.276	0.396	0.270	0.535	0.300	0.604	0.372	0.494	0.354	0.434	0.295	0.518	0.383	0.587	0.378	0.466	0.348	0.620	0.336	0.622	0.392	0.535	0.312
Weather	96	**0.141**	**0.188**	**0.147**	**0.198**	0.160	0.198	0.153	0.204	0.171	0.209	0.149	0.200	0.153	0.217	0.238	0.314	0.156	0.206	0.152	0.237	0.175	0.225	0.178	0.233	0.149	0.202	0.172	0.220	0.182	0.242	0.161	0.226
	192	**0.185**	**0.231**	**0.189**	**0.240**	0.203	0.239	0.202	0.250	0.220	0.252	0.196	0.245	0.197	0.269	0.275	0.329	0.199	0.248	0.220	0.282	0.218	0.260	0.235	0.277	0.194	0.242	0.219	0.261	0.227	0.287	0.220	0.283
	336	**0.231**	**0.270**	0.245	0.280	0.252	0.276	0.245	0.283	0.275	0.294	**0.238**	**0.277**	0.252	0.311	0.339	0.377	0.249	0.291	0.265	0.319	0.265	0.294	0.337	0.345	0.243	0.282	0.280	0.306	0.282	0.334	0.275	0.328
	720	**0.306**	**0.323**	**0.310**	**0.330**	0.326	0.328	0.323	0.341	0.353	0.344	0.314	0.334	0.318	0.363	0.389	0.409	0.336	0.343	0.323	0.362	0.329	0.339	0.396	0.413	0.316	0.333	0.365	0.359	0.352	0.386	0.311	0.356
Avg		**0.216**	**0.253**	**0.223**	**0.262**	0.235	0.260	0.231	0.270	0.255	0.275	0.224	0.264	0.230	0.290	0.310	0.357	0.235	0.272	0.240	0.300	0.247	0.280	0.287	0.317	0.226	0.265	0.259	0.287	0.261	0.312	0.242	0.298
Exchange	96	**0.083**	**0.197**	0.081	0.200	0.087	0.206	0.082	0.200	0.087	0.206	0.080	0.196	0.186	0.346	0.139	0.276	0.083	0.201	0.081	0.203	0.083	0.201	0.116	0.254	0.083	0.201	0.107	0.234	0.116	0.262	0.102	0.235
	192	**0.171**	**0.289**	0.177	0.298	0.171	0.295	0.171	0.294	0.179	0.301	0.166	0.288	0.467	0.522	0.256	0.369	0.174	0.296	0.157	0.293	0.170	0.293	0.218	0.345	0.170	0.292	0.226	0.344	0.215	0.359	0.172	0.316
	336	**0.311**	**0.405**	0.344	0.424	0.285	0.389	0.316	0.406	0.336	0.417	0.307	0.398	0.783	0.721	0.426	0.464	0.336	0.417	0.305	0.414	0.309	0.401	0.294	0.413	0.309	0.401	0.367	0.448	0.377	0.466	0.272	0.407
	720	**0.632**	**0.558**	0.925	0.723	**0.578**	**0.574**	0.676	0.594	0.857	0.692	0.656	0.582	1.367	0.943	1.090	0.800	0.900	0.715	0.643	0.601	0.817	0.680	1.110	0.767	0.816	0.680	0.964	0.746	0.831	0.699	0.714	0.658
Avg		**0.299**	**0.362**	0.382	0.411	0.280	0.366	0.311	0.374	0.365	0.404	0.302	0.366	0.701	0.633	0.478	0.477	0.373	0.407	0.297	0.378	0.345	0.394	0.435	0.445	0.345	0.394	0.416	0.443	0.385	0.447	0.315	0.404

1 Full result

1.1 Long-term forecasting

Comprehensive forecasting results are summarized in Table 1.1, with the best performances highlighted in red and the second-best in blue. Lower MSE and MAE values indicate more accurate predictions. TCDNet consistently achieves the lowest MSE and MAE across nearly all datasets, underscoring its superior predictive accuracy. Notably, TCDNet also shows superior performance on the Weather and Exchange datasets, achieving significantly lower MSE and MAE values compared to other models. Overall, TCDNet improves the average percentages for MAE and MSE on all tasks by 7.12% and 8.23%, respectively, demonstrating not only lower error metrics but also greater reliability and efficiency in diverse time series forecasting scenarios.

1.2 Short-term forecasting

For the Heat datasets, the input sequence length is set to 12, whereas for the PEMS datasets, it is set to 360. For other models, the input sequence length is searched to the best for a fairer comparison.

Table 1.2 summarizes the results of multivariate short-term forecasting across various datasets, including Heat Load (HL) and PEMS. The results demonstrate that TCDNet provides superior performance in short-term forecasting tasks compared to other models, making it a robust choice for handling complex time series data. The inductor mechanism in TCDNet ensures a balanced information flow throughout the model, preventing critical information from being lost during the compression and decompression phases. This balance is vital for maintaining the integrity of the forecasted data, especially in short-term horizons where small inaccuracies can significantly impact overall performance. Models like TimeMixer and UnetTST may suffer from information loss, leading to less reliable predictions.

1.3 Imputation

Table 1.3 summarizes the results of the imputation task across six datasets with mask ratios of 10%, 25%, 50%, and 75%. TCDNet shows significant MSE improvements ranging from 3.66% to 62.15% (average 23.55%) and MAE improvements from 5.28% to 40.80% (average 17.65%). Notably, TCDNet excels particularly on ETTh1 and ETTm1, while it slightly underperforms on ETTh2 in terms of MSE but still improves on MAE. These results demonstrate that TCDNet provides superior performance in imputing missing values across various datasets and mask ratios, making it a robust choice for handling missing data in time series forecasting. TCDNet leverages an inductor mechanism to weigh the importance of different parts of the time series. This capability is crucial for accurately estimating missing values based on

TABLE 1.2: The results for short-term forecasting are summarized across all datasets. For the HL datasets, the input sequence length is set to 12, whereas for the PEMS datasets, it is set to 360. The forecasting horizons: 4, 6, 12, and 24. Lower values indicate better model performance.

Methods		TCDNet (Our)		TimeMixer (2024)		UnetTS (2024)		iTransformer (2024)		Crossformer (2023)		PatchTST (2023)		FEDformer (2022)		TSmixer (2023)		MICN (2023)		TimesNet (2023)		Dlinear (2023)		Rlinear (2023)		TiDE (2023)		SCINet (2022)	
Metric		RMSE	MAPE	RMSE	MAPE	RMSE	MAPE	RMSE	MAPE	RMSE	MAPE	RMSE	MAPE	RMSE	MAPE	RMSE	MAPE	RMSE	MAPE	RMSE	MAPE	RMSE	MAPE	RMSE	MAPE	RMSE	MAPE	RMSE	MAPE
Heat1	4	**0.034**	**1.08**	0.075	1.54	0.091	2.01	0.083	2.24	0.167	3.09	0.154	2.84	0.086	1.60	0.085	2.30	0.082	2.19	0.129	3.49	0.152	2.75	0.144	3.87	0.185	4.99	0.079	2.12
	6	**0.053**	**1.64**	0.100	1.95	0.132	3.11	0.106	2.80	0.213	3.92	0.196	3.61	0.110	2.03	0.109	2.89	0.105	2.75	0.165	4.37	0.194	3.45	0.183	4.85	0.236	6.25	0.101	2.66
	12	**0.137**	**4.44**	0.152	4.05	0.184	5.13	0.174	4.61	0.350	8.15	0.322	7.49	0.181	4.21	0.179	4.75	0.172	4.52	0.271	7.20	0.318	5.67	0.301	7.98	0.388	10.3	0.165	4.38
	24	**0.250**	**8.50**	0.285	8.76	0.293	8.25	0.296	8.04	0.595	17.6	0.548	16.2	0.308	9.11	0.305	8.28	0.293	7.88	0.462	12.5	0.542	9.89	0.512	13.9	0.660	17.9	0.281	7.64
Avg		**0.119**	**3.92**	0.153	4.07	0.175	4.62	0.165	4.42	0.331	8.19	0.305	7.54	0.171	4.24	0.170	4.55	0.163	4.33	0.257	6.90	0.302	5.44	0.285	7.65	0.367	9.86	0.157	4.20
Heat2	4	**0.030**	**1.08**	0.045	1.11	0.085	2.14	0.068	2.02	0.137	2.2	0.126	2.04	0.071	1.15	0.070	2.08	0.069	2.04	0.062	1.84	0.124	2.49	0.118	3.50	0.152	4.51	0.065	1.92
	6	**0.053**	**1.64**	0.065	1.68	0.105	3.71	0.901	2.61	1.812	3.4	1.667	3.11	0.937	1.75	0.928	2.69	0.910	2.64	0.820	2.38	1.649	3.21	1.559	4.52	2.009	5.82	0.856	2.48
	12	**0.118**	**3.97**	0.141	4.10	0.188	5.31	0.163	4.44	0.328	8.2	0.302	7.59	0.170	4.26	0.168	4.57	0.165	4.48	0.148	4.04	0.298	5.46	0.282	7.68	0.363	9.90	0.155	4.22
	24	**0.250**	**9.10**	0.291	9.21	0.301	8.47	0.291	8.01	0.585	18.5	0.538	17.0	0.303	9.58	0.300	8.25	0.294	8.09	0.265	7.29	0.533	9.85	0.503	13.9	0.649	17.9	0.276	7.61
Avg		**0.113**	**3.95**	0.136	4.02	0.170	4.91	0.356	4.27	0.716	8.1	0.658	7.44	0.370	4.18	0.367	4.40	0.360	4.31	0.324	3.89	0.651	5.25	0.616	7.39	0.793	9.52	0.338	4.06
Heat3	4	**0.045**	**1.13**	0.057	1.31	0.089	2.41	0.080	2.29	0.161	2.6	0.148	2.42	0.083	1.36	0.082	2.36	0.079	2.24	0.082	2.36	0.146	2.82	0.138	3.96	0.178	5.11	0.076	2.18
	6	**0.073**	**1.81**	0.084	2.03	0.101	3.13	0.107	3.30	0.215	4.1	0.198	3.76	0.111	2.11	0.110	3.40	0.106	3.23	0.110	3.40	0.196	4.06	0.185	5.71	0.239	7.36	0.102	3.14
	12	**0.142**	**4.66**	0.175	4.77	0.204	5.73	0.182	5.04	0.366	9.6	0.337	8.83	0.189	4.96	0.187	5.19	0.180	4.94	0.187	5.19	0.333	6.20	0.315	8.72	0.406	11.2	0.173	4.79
	24	**0.278**	**10.01**	0.301	10.12	0.324	10.3	0.316	8.68	0.636	20.4	0.585	18.7	0.329	10.5	0.325	8.94	0.313	8.51	0.325	8.94	0.578	10.7	0.547	15.02	0.705	19.4	0.300	8.25
Avg		**0.135**	**4.40**	0.154	4.56	0.180	5.39	0.171	4.83	0.345	9.16	0.317	8.43	0.178	4.74	0.176	4.97	0.170	4.73	0.176	4.97	0.313	5.94	0.296	8.35	0.382	10.8	0.163	4.59
Heat4	4	**0.054**	**1.61**	0.081	1.64	1.101	3.30	0.099	2.83	0.199	3.30	0.183	3.03	0.103	1.71	0.102	2.92	0.098	2.77	0.094	2.69	0.181	3.48	0.171	4.90	0.221	6.31	0.094	2.69
	6	**0.082**	**2.49**	0.153	3.42	0.181	3.98	0.123	3.49	0.248	6.88	0.228	6.33	0.128	3.56	0.127	3.60	0.122	3.42	0.117	3.32	0.226	4.29	0.213	6.04	0.275	7.78	0.117	3.32
	12	**0.162**	**5.01**	0.190	5.11	0.224	6.47	0.208	5.80	0.418	10.3	0.385	9.45	0.216	5.31	0.214	5.97	0.206	5.68	0.198	5.51	0.381	7.13	0.360	10.0	0.464	12.9	0.198	5.51
	24	**0.304**	**12.1**	0.347	12.2	0.340	12.2	0.349	12.2	0.702	24.6	0.646	22.6	0.363	12.7	0.359	12.6	0.346	12.0	0.332	11.6	0.639	15.1	0.604	21.2	0.778	27.3	0.332	11.6
Avg		**0.151**	**5.30**	0.193	5.60	0.462	6.49	0.195	6.09	0.392	11.3	0.361	10.4	0.203	5.82	0.201	6.27	0.193	5.97	0.185	5.79	0.357	7.49	0.337	10.5	0.435	13.6	0.185	5.79
PESM04	4	0.261	35.1	**0.265**	**35.3**	0.292	39.01	0.257	34.2	0.517	71.0	0.475	65.3	0.267	36.7	0.265	35.2	0.262	34.9	0.260	35.2	0.470	42.1	0.445	59.2	0.573	76.3	0.260	34.6
	6	0.271	36.4	**0.252**	**34.0**	0.330	39.71	0.267	35.6	0.537	68.4	0.494	62.9	0.278	35.4	0.275	36.7	0.272	36.3	0.272	36.7	0.489	43.8	0.462	61.6	0.595	79.4	0.270	36.0
	12	0.302	38.8	**0.269**	**36.0**	0.351	43.98	0.299	38.5	0.601	72.3	0.553	66.5	0.311	37.4	0.308	39.7	0.305	39.3	0.305	39.7	0.547	47.4	0.517	66.6	0.667	85.9	0.302	38.9
	24	0.340	40.1	**0.305**	**39.5**	0.471	53.13	0.360	43.8	0.724	79.4	0.666	73.0	0.374	41.1	0.371	45.1	0.367	44.7	0.367	45.1	0.659	53.9	0.623	75.8	0.803	97.7	0.364	44.3
Avg		0.294	37.6	**0.275**	**36.5**	0.361	43.96	0.296	38.0	0.595	72.8	0.547	67.0	0.308	37.6	0.305	39.2	0.302	38.8	0.301	39.2	0.541	46.8	0.512	65.8	0.660	84.8	0.299	38.4
PESM08	4	**0.239**	**34.0**	0.241	34.1	0.285	39.53	0.238	34.0	0.479	68.6	0.441	63.1	0.248	35.5	0.246	35.0	0.236	33.3	0.241	35.0	0.436	41.8	0.412	58.8	0.532	75.7	0.241	34.3
	6	**0.251**	**34.1**	0.259	34.7	0.305	40.53	0.256	35.0	0.515	69.8	0.474	64.3	0.266	36.1	0.264	36.0	0.253	34.3	0.261	36.0	0.468	43.0	0.443	60.5	0.571	78.0	0.259	35.3
	12	**0.275**	**36.7**	0.281	37.3	0.347	44.49	0.282	37.4	0.567	74.9	0.522	68.9	0.293	38.7	0.290	38.5	0.279	36.6	0.288	38.5	0.516	46.0	0.488	64.7	0.629	83.4	0.285	37.8
	24	**0.327**	**41.0**	0.334	43.9	0.462	53.35	0.338	42.6	0.680	88.2	0.625	81.1	0.352	45.6	0.348	43.9	0.335	41.8	0.345	43.9	0.619	52.4	0.585	73.7	0.754	95.0	0.341	43.0
Avg		**0.273**	**36.4**	0.279	37.5	0.350	44.48	0.279	37.2	0.560	75.4	0.516	69.4	0.290	39.0	0.287	38.4	0.276	36.5	0.284	38.4	0.510	45.8	0.482	64.4	0.622	83.0	0.282	37.6

surrounding data, enhancing its effectiveness in imputation tasks.

The varying time series lengths enable TCDNet to handle diverse data complexities and scales. This flexibility ensures that the model can be applied to a wide range of real-world scenarios. Testing the model under different conditions also verifies its robust performance across various types of data, which is essential for practical applications where data characteristics can vary significantly.

1.4 Few-shot forecasting

Table 1.4 summarizes the results, showing TCDNet consistently outperforming other models in MSE and MAE across all datasets. For example, on ETTh1, TCDNet surpasses UnetTST by 75.84% in MSE and 28.42% in MAE. Overall, TCDNet achieves an average improvement of 60.12% in MSE and 42.13% in MAE compared to second-best models. Notably, simpler models like TCDNet often outperform more complex Transformer-based models in few-shot learning scenarios, suggesting that added complexity may not be fully leveraged with limited training data. The combination of these unique design elements—efficient handling of redundant feature information, innovative MKFE blocks, and the inductor mechanism for minimizing information loss—enables TCDNet to achieve superior performance in few-shot forecasting. These advantages allow TCDNet to generalize better with limited training data, capturing intricate temporal patterns and maintaining high accuracy across various datasets and forecasting lengths. As a result, TCDNet stands out as a reliable and effective choice for time series forecasting tasks, especially in resource-constrained environments.

References

[1] Y. Liu, T. Hu, H. Zhang, H. Wu, S. Wang, L. Ma, and M. Long, "itransformer: Inverted transformers are effective for time series forecasting," in *ICLR*, 2024. [Online]. Available: https://arxiv.org/abs/2310.06625

[2] Y. Zhang and J. Yan, "Crossformer: Transformer utilizing cross-dimension dependency for multivariate time series forecasting," in *ICLR*, 2023.

[3] T. Zhou, Z. Ma, Q. Wen, X. Wang, L. Sun, and R. Jin, "Fedformer: Frequency enhanced decomposed transformer for long-term series forecasting," *International Conference on Machine Learning*, pp. 27 268–27 286, 2022.

[4] N. Nie *et al.*, "A time series is worth 64 words: Long-term forecasting with transformers," in *ICLR*, 2023. [Online]. Available: https://arxiv.org/abs/2211.14730

[5] A. Zeng, M. Chen, L. Zhang, and Q. Xu, "Are transformers effective for time series forecasting?" in *Proceedings of the AAAI Conference on Artificial Intelligence*. AAAI, 2023.

[6] A. Das, W. Kong, A. Leach, R. Sen, and R. Yu, "Long-term forecasting with tide: Time-series dense encoder," 2023.

[7] Z. Li, S. Qi, Y. Li, and Z. Xu, "Revisiting long-term time series forecasting: An investigation on linear mapping," *ArXiv*, vol. abs/2305.10721, 2023.

[8] ——, "Revisiting long-term time series forecasting: An investigation on linear mapping," 2023.

[9] M. Liu, A. Zeng, M. Chen, Z. Xu, Q. Lai, L. Ma, and Q. Xu, "Scinet: Time series modeling and forecasting with sample convolution and interaction," in *Advances in Neural Information Processing Systems*. NeurIPS, 2022.

TABLE 1.3: The result of the imputation. The mask ration: 10%, 25%, 50%, and 75%.

Methods		TCDNet (Our)		TimeMixer (2024)		UnetTS (2024)		iTransformer (2024)		Crossformer (2023)		PatchTST (2023)		FEDformer (2022)		TSmixer (2023)		MICN (2023)		TimesNet (2023)		Dlinear (2023)		Rlinear (2023)		TiDE (2023)		SCINet (2022)	
Metric		MSE	MAE	MSE	MAE	MSE	MAE	MSE	MAE	MSE	MAE	MSE	MAE	MSE	MAE	MSE	MAE	MSE	MAE	MSE	MAE	MSE	MAE	MSE	MAE	MSE	MAE	MSE	MAE
ETTh1	0.1	**0.079**	**0.195**	0.362	0.430	0.136	0.262	0.154	0.289	0.310	0.865	0.285	0.796	0.160	0.447	0.189	0.355	0.214	0.402	0.240	0.451	0.282	0.355	0.266	0.500	0.343	0.644	0.220	0.413
	0.25	**0.105**	**0.225**	0.376	0.438	0.157	0.283	0.202	0.339	0.406	0.881	0.374	0.810	0.210	0.456	0.248	0.417	0.281	0.471	0.315	0.529	0.370	0.417	0.349	0.586	0.450	0.756	0.289	0.485
	0.5	**0.147**	**0.266**	0.347	0.419	0.248	0.363	0.332	0.430	0.668	0.843	0.614	0.775	0.345	0.436	0.408	0.529	0.461	0.598	0.518	0.671	0.608	0.529	0.574	0.744	0.740	0.959	0.475	0.615
	0.75	0.206	0.317	0.330	0.410	0.422	0.497	0.450	0.510	0.905	0.825	0.833	0.759	0.468	0.426	0.554	0.627	0.626	0.709	0.702	0.796	0.824	0.627	0.779	0.882	1.004	1.137	0.644	0.729
Avg		**0.134**	**0.251**	0.354	0.424	0.276	0.381	0.285	0.392	0.572	0.854	0.527	0.785	0.296	0.441	0.350	0.482	0.396	0.545	0.444	0.612	0.521	0.482	0.492	0.678	0.634	0.874	0.407	0.561
ETTh2	0.1	**0.065**	**0.173**	0.124	0.243	0.126	0.243	0.133	0.231	0.267	0.489	0.246	0.450	0.138	0.253	0.164	0.284	0.185	0.321	0.121	0.210	0.243	0.284	0.230	0.400	0.297	0.515	0.190	0.330
	0.25	**0.096**	**0.210**	0.123	0.242	0.340	0.401	0.161	0.255	0.324	0.487	0.298	0.448	0.167	0.252	0.198	0.314	0.224	0.354	0.147	0.232	0.295	0.314	0.279	0.441	0.359	0.569	0.230	0.365
	0.5	**0.151**	**0.260**	0.127	0.246	0.980	0.735	0.182	0.298	0.366	0.495	0.337	0.455	0.189	0.256	0.224	0.367	0.253	0.414	0.166	0.271	0.333	0.367	0.315	0.516	0.406	0.665	0.260	0.426
	0.75	**0.320**	**0.289**	0.131	0.251	1.988	1.077	0.210	0.322	0.422	0.505	0.389	0.464	0.218	0.261	0.258	0.396	0.292	0.448	0.191	0.293	0.384	0.396	0.363	0.557	0.468	0.718	0.300	0.460
Avg		**0.158**	0.233	**0.126**	0.246	0.519	0.614	0.172	0.277	0.345	0.494	0.318	0.454	0.178	0.256	0.211	0.340	0.239	0.384	0.156	0.252	0.314	0.340	0.297	0.479	0.383	0.617	0.245	0.395
ETTm1	0.1	**0.046**	**0.147**	0.102	0.220	0.103	0.214	0.106	0.229	0.213	0.442	0.196	0.407	0.110	0.229	0.130	0.282	0.147	0.318	0.096	0.208	0.194	0.282	0.183	0.396	0.236	0.511	0.152	0.327
	0.25	**0.063**	**0.174**	0.096	0.217	0.113	0.216	0.100	0.226	0.201	0.436	0.185	0.401	0.104	0.226	0.123	0.278	0.139	0.314	0.091	0.206	0.183	0.278	0.173	0.391	0.223	0.504	0.143	0.323
	0.5	**0.090**	**0.214**	0.114	0.234	0.188	0.275	0.119	0.243	0.239	0.471	0.220	0.433	0.124	0.243	0.146	0.299	0.165	0.338	0.108	0.221	0.218	0.299	0.206	0.420	0.265	0.542	0.170	0.347
	0.75	**0.151**	**0.268**	0.141	0.258	0.791	0.575	0.147	0.268	0.296	0.519	0.272	0.477	0.153	0.268	0.181	0.330	0.204	0.373	0.134	0.244	0.269	0.330	0.254	0.464	0.328	0.598	0.210	0.383
Avg		**0.088**	**0.201**	0.113	0.232	0.299	0.320	0.118	0.242	0.237	0.467	0.218	0.430	0.123	0.242	0.145	0.297	0.164	0.336	0.107	0.220	0.216	0.297	0.204	0.418	0.263	0.539	0.169	0.345
Google	0.1	**0.016**	**0.085**	0.031	0.125	0.079	0.184	0.029	0.119	0.058	0.251	0.054	0.231	0.030	0.130	0.036	0.146	0.040	0.165	0.028	0.113	0.053	0.146	0.050	0.206	0.065	0.265	0.041	0.170
	0.25	**0.017**	**0.091**	0.019	0.094	0.113	0.216	0.018	0.089	0.036	0.189	0.033	0.174	0.019	0.098	0.022	0.109	0.025	0.124	0.017	0.085	0.033	0.109	0.031	0.154	0.040	0.198	0.026	0.127
	0.5	0.041	0.139	**0.035**	**0.112**	0.188	0.275	0.033	0.106	0.066	0.225	0.061	0.207	0.034	0.116	0.041	0.130	0.046	0.147	0.031	0.101	0.060	0.130	0.057	0.183	0.074	0.236	0.047	0.152
	0.75	**0.078**	**0.195**	0.080	0.211	0.312	0.411	0.076	0.200	0.153	0.424	0.141	0.390	0.079	0.219	0.093	0.246	0.106	0.278	0.072	0.190	0.139	0.246	0.131	0.346	0.169	0.446	0.109	0.286
Avg		0.038	0.128	0.041	0.136	0.173	0.272	0.039	0.129	0.078	0.272	0.072	0.251	0.041	0.141	0.048	0.158	0.054	0.179	0.037	0.122	0.071	0.158	0.067	0.222	0.087	0.286	0.056	0.184
EX	0.1	**0.027**	**0.118**	0.087	0.21	0.047	0.154	0.091	0.221	0.183	0.422	0.168	0.389	0.095	0.218	0.112	0.272	0.126	0.307	0.086	0.210	0.167	0.272	0.157	0.382	0.203	0.493	0.130	0.316
	0.25	**0.048**	**0.156**	0.085	0.207	0.077	0.190	0.089	0.217	0.179	0.416	0.165	0.383	0.093	0.215	0.109	0.267	0.124	0.302	0.085	0.206	0.163	0.267	0.154	0.375	0.198	0.484	0.127	0.310
	0.5	**0.085**	**0.208**	0.090	0.213	1.080	0.841	0.095	0.224	0.191	0.428	0.176	0.394	0.099	0.222	0.117	0.276	0.132	0.311	0.091	0.213	0.174	0.276	0.164	0.388	0.212	0.500	0.136	0.320
	0.75	0.154	0.271	0.071	0.190	2.900	1.470	0.075	0.200	0.151	0.382	0.139	0.352	0.078	0.198	0.092	0.246	0.104	0.278	0.072	0.190	0.137	0.246	0.130	0.346	0.167	0.446	0.107	0.286
Avg		**0.079**	**0.188**	0.082	0.203	1.026	0.664	0.088	0.216	0.176	0.412	0.162	0.380	0.091	0.213	0.108	0.265	0.122	0.300	0.084	0.205	0.160	0.265	0.151	0.373	0.195	0.481	0.125	0.308
Weather	0.1	**0.032**	**0.074**	0.095	0.151	0.034	0.081	0.099	0.157	0.199	0.304	0.183	0.279	0.103	0.157	0.122	0.193	0.138	0.218	0.066	0.105	0.181	0.193	0.171	0.272	0.221	0.350	0.142	0.225
	0.25	**0.040**	**0.094**	0.112	0.162	0.041	0.101	0.116	0.168	0.233	0.326	0.215	0.300	0.121	0.168	0.143	0.207	0.161	0.234	0.078	0.113	0.212	0.207	0.201	0.291	0.259	0.375	0.166	0.240
	0.5	**0.054**	**0.122**	0.116	0.167	0.061	0.141	0.121	0.174	0.243	0.336	0.224	0.309	0.126	0.174	0.149	0.214	0.168	0.242	0.081	0.117	0.221	0.214	0.209	0.301	0.270	0.388	0.173	0.249
	0.75	**0.083**	**0.171**	0.112	0.159	0.122	0.226	0.116	0.165	0.233	0.320	0.215	0.294	0.121	0.165	0.143	0.203	0.161	0.229	0.078	0.111	0.212	0.203	0.201	0.285	0.259	0.368	0.166	0.236
Avg		**0.052**	**0.115**	0.109	0.160	0.065	0.137	0.113	0.166	0.227	0.322	0.209	0.296	0.118	0.166	0.139	0.204	0.157	0.231	0.076	0.112	0.207	0.204	0.196	0.287	0.252	0.370	0.162	0.238

TABLE 1.4: Few-shot learning on 10% training data. The results across four forecasting lengths: 96, 192, 336, and 720.

Methods		TCDNet (Our)		TimeMixer (2024)		UnetTS (2024)		iTransformer (2024)		Crossformer (2023)		PatchTST (2023)		FEDformer (2022)		TSmixer (2023)		MICN (2023)		TimesNet (2023)		Dlinear (2023)		Rlinear (2023)		TiDE (2023)		SCINet (2022)	
ETTh1	96	**0.402**	**0.426**	0.510	0.530	0.474	0.493	0.571	0.594	0.685	0.636	0.657	0.610	0.651	0.604	0.703	0.730	0.794	0.825	0.577	0.600	0.588	0.611	0.988	1.027	0.628	0.659	0.645	0.671
	192	**0.439**	**0.449**	0.550	0.572	0.512	0.531	0.616	0.640	0.739	0.686	0.708	0.657	0.702	0.652	0.758	0.787	0.856	0.890	0.622	0.646	0.634	0.659	1.066	1.107	0.678	0.710	0.881	0.915
	336	**0.423**	**0.446**	0.570	0.648	0.530	0.603	0.638	0.726	0.766	0.778	0.734	0.745	0.728	0.739	0.785	0.893	0.887	1.009	0.645	0.733	0.658	0.748	1.104	1.256	0.702	0.806	0.913	1.038
	720	**0.487**	**0.488**	0.620	0.822	0.577	0.764	0.694	0.921	0.833	0.986	0.799	0.945	0.792	0.937	0.854	1.132	0.965	1.280	0.701	0.930	0.715	0.948	1.201	1.593	0.764	1.022	0.993	1.317
Avg		**0.438**	**0.452**	0.563	0.643	0.539	0.633	0.630	0.720	0.756	0.772	0.725	0.739	0.718	0.733	0.775	0.886	0.876	1.001	0.636	0.727	0.649	0.742	1.090	1.246	0.693	0.799	0.858	0.985
ETTh2	96	**0.273**	**0.336**	0.344	0.497	0.320	0.462	0.386	0.557	0.463	0.597	0.443	0.572	0.440	0.567	0.474	0.685	0.536	0.774	0.351	0.507	0.397	0.574	0.667	0.963	0.424	0.618	0.436	0.629
	192	**0.345**	**0.384**	0.396	0.516	0.368	0.480	0.444	0.577	0.532	0.619	0.510	0.593	0.506	0.588	0.546	0.710	0.617	0.803	0.404	0.525	0.457	0.595	0.767	0.999	0.488	0.641	0.634	0.826
	336	**0.331**	**0.383**	0.568	0.627	0.528	0.583	0.636	0.702	0.764	0.752	0.732	0.721	0.725	0.715	0.783	0.863	0.884	0.976	0.579	0.639	0.655	0.723	1.101	1.214	0.700	0.779	0.910	1.004
	720	**0.496**	**0.476**	0.597	0.652	0.555	0.607	0.669	0.731	0.803	0.783	0.769	0.750	0.763	0.744	0.823	0.899	0.930	1.016	0.609	0.665	0.689	0.753	1.157	1.264	0.736	0.811	0.957	1.045
Avg		**0.361**	**0.395**	0.476	0.573	0.489	0.533	0.534	0.642	0.641	0.688	0.614	0.659	0.609	0.654	0.657	0.789	0.742	0.892	0.486	0.584	0.550	0.661	0.923	1.110	0.587	0.712	0.734	0.876
ETTm1	96	**0.290**	**0.350**	0.332	0.382	0.309	0.355	0.372	0.428	0.365	0.375	0.428	0.439	0.424	0.436	0.457	0.526	0.517	0.595	0.338	0.389	0.383	0.441	0.643	0.740	0.409	0.475	0.420	0.484
	192	**0.342**	**0.371**	0.392	0.442	0.364	0.411	0.439	0.495	0.431	0.434	0.505	0.508	0.500	0.504	0.540	0.609	0.610	0.688	0.399	0.450	0.452	0.510	0.759	0.856	0.483	0.549	0.628	0.708
	336	**0.376**	**0.392**	0.441	0.491	0.410	0.456	0.493	0.549	0.484	0.481	0.567	0.564	0.562	0.559	0.607	0.676	0.686	0.764	0.449	0.500	0.508	0.566	0.854	0.950	0.543	0.610	0.706	0.786
	720	**0.441**	**0.427**	0.508	0.558	0.472	0.519	0.569	0.625	0.558	0.547	0.654	0.642	0.649	0.636	0.700	0.769	0.791	0.869	0.518	0.569	0.586	0.644	0.984	1.081	0.626	0.694	0.814	0.894
Avg		**0.362**	**0.385**	0.418	0.468	0.389	0.435	0.468	0.524	0.460	0.459	0.539	0.538	0.534	0.534	0.576	0.645	0.651	0.729	0.426	0.477	0.482	0.540	0.810	0.907	0.515	0.582	0.642	0.718
ETTm2	96	**0.163**	**0.249**	0.259	0.372	0.241	0.346	0.290	0.416	0.284	0.365	0.333	0.427	0.330	0.424	0.356	0.512	0.403	0.579	0.264	0.379	0.298	0.429	0.501	0.720	0.319	0.462	0.327	0.470
	192	**0.216**	**0.286**	0.281	0.394	0.262	0.367	0.315	0.442	0.309	0.387	0.362	0.453	0.359	0.449	0.387	0.543	0.438	0.614	0.287	0.402	0.324	0.455	0.545	0.764	0.346	0.490	0.450	0.631
	336	**0.273**	**0.324**	0.401	0.514	0.373	0.478	0.450	0.576	0.441	0.505	0.517	0.592	0.512	0.586	0.553	0.709	0.625	0.801	0.409	0.524	0.463	0.593	0.778	0.997	0.494	0.639	0.643	0.824
	720	**0.367**	**0.382**	0.391	0.504	0.364	0.469	0.438	0.565	0.430	0.495	0.504	0.580	0.500	0.575	0.539	0.695	0.609	0.785	0.399	0.514	0.451	0.582	0.758	0.977	0.482	0.627	0.627	0.808
Avg		**0.255**	**0.310**	0.333	0.446	0.310	0.415	0.373	0.500	0.366	0.438	0.429	0.513	0.425	0.509	0.459	0.615	0.519	0.695	0.340	0.455	0.384	0.515	0.646	0.865	0.410	0.555	0.512	0.683
Electricty	96	**0.544**	**0.576**	0.240	0.290	0.223	0.270	0.215	0.302	0.432	0.584	0.247	0.334	0.224	0.302	0.264	0.371	0.299	0.420	0.196	0.275	0.221	0.311	0.372	0.522	0.237	0.335	0.307	0.432
	192	**1.011**	**0.624**	0.350	0.400	0.325	0.372	0.392	0.448	0.787	0.804	0.450	0.460	0.407	0.416	0.482	0.550	0.544	0.622	0.352	0.313	0.403	0.461	0.677	0.774	0.431	0.497	0.560	0.640
	336	**1.434**	**0.865**	0.475	0.525	0.442	0.488	0.532	0.588	1.070	1.056	0.612	0.604	0.553	0.546	0.655	0.723	0.740	0.818	0.490	0.541	0.548	0.606	0.921	1.018	0.585	0.653	0.761	0.841
	720	**2.330**	**1.112**	0.360	0.410	0.335	0.381	0.403	0.459	0.811	0.825	0.464	0.472	0.419	0.427	0.496	0.565	0.561	0.638	0.367	0.418	0.415	0.473	0.698	0.795	0.444	0.510	0.577	0.657
Avg		**1.330**	**0.794**	0.395	0.445	0.331	0.378	0.386	0.449	0.775	0.817	0.443	0.468	0.401	0.423	0.474	0.552	0.536	0.625	0.351	0.387	0.397	0.463	0.667	0.777	0.424	0.499	0.551	0.643
Weather	96	**0.147**	**0.191**	0.253	0.303	0.235	0.281	0.240	0.306	0.483	0.608	0.276	0.348	0.250	0.315	0.295	0.376	0.334	0.425	0.161	0.205	0.247	0.315	0.415	0.529	0.264	0.339	0.343	0.437
	192	**0.187**	**0.231**	0.307	0.357	0.286	0.332	0.292	0.361	0.587	0.719	0.336	0.411	0.304	0.372	0.359	0.444	0.406	0.502	0.196	0.242	0.301	0.372	0.505	0.624	0.321	0.401	0.418	0.516
	336	**0.232**	**0.270**	0.355	0.405	0.330	0.376	0.337	0.409	0.678	0.814	0.388	0.466	0.351	0.421	0.415	0.503	0.469	0.568	0.236	0.274	0.347	0.421	0.583	0.707	0.371	0.454	0.482	0.585
	720	**0.310**	**0.324**	0.454	0.504	0.422	0.469	0.432	0.509	0.868	1.014	0.496	0.580	0.449	0.524	0.531	0.626	0.600	0.708	0.345	0.341	0.445	0.525	0.747	0.881	0.475	0.565	0.617	0.728
Avg		**0.219**	**0.254**	0.342	0.392	0.318	0.365	0.325	0.396	0.654	0.789	0.374	0.451	0.339	0.408	0.400	0.487	0.452	0.551	0.235	0.266	0.335	0.408	0.563	0.685	0.358	0.440	0.465	0.567

TABLE 1.5: Zero-shot learning results. The results are averaged from four different prediction lengths: 96, 192, 336, and 720.

Methods	**TCDNet (Our)**		TimeMixer (2024)		UnetTS (2024)		iTransformer (2024)		Crossformer (2023)		PatchTST (2023)		FEDformer (2022)		TSmixer (2023)		MICN (2023)		TimesNet (2023)		Dlinear (2023)		Rlinear (2023)		TiDE (2023)		SCINet (2022)	
Metric	MSE	MAE	MSE	MAE	MSE	MAE	MSE	MAE	MSE	MAE	MSE	MAE	MSE	MAE	MSE	MAE	MSE	MAE	MSE	MAE	MSE	MAE	MSE	MAE	MSE	MAE	MSE	MAE
ETTh1→h2	**0.311**	**0.368**	0.423	0.420	0.342	0.405	0.476	0.469	0.549	0.568	0.374	0.395	0.524	0.516	0.538	0.557	0.486	0.514	0.479	0.471	0.495	0.529	0.448	0.488	0.441	0.447	0.456	0.503
ETTh1-m2	**0.295**	**0.351**	0.298	0.353	0.325	0.386	0.308	0.357	0.634	0.681	0.318	0.360	0.339	0.393	0.621	0.667	0.413	0.468	0.312	0.363	0.572	0.634	0.380	0.445	0.287	0.345	0.526	0.602
ETTh2→h1	0.535	0.502	0.506	0.493	0.589	0.552	0.546	0.506	0.593	0.605	0.540	0.499	0.601	0.556	0.581	0.593	0.701	0.649	0.561	0.551	0.535	0.563	0.645	0.616	0.516	0.523	0.492	0.535
ETTm1→h2	**0.340**	**0.389**	0.413	0.418	0.374	0.428	0.430	0.434	0.625	0.545	0.427	0.431	0.473	0.477	0.612	0.535	0.555	0.560	0.411	0.421	0.563	0.508	0.510	0.532	0.378	0.400	0.518	0.482
ETTm1→m2	**0.263**	**0.317**	0.288	0.328	0.289	0.349	0.321	0.328	0.575	0.557	0.298	0.338	0.353	0.360	0.564	0.546	0.387	0.439	0.332	0.354	0.519	0.519	0.356	0.417	0.305	0.336	0.477	0.493
ETTm2→m1	**0.429**	**0.430**	0.423	0.444	0.472	0.473	0.553	0.486	0.585	0.581	0.552	0.482	0.609	0.535	0.573	0.570	0.608	0.530	0.754	0.553	0.528	0.541	0.559	0.504	0.694	0.525	0.485	0.514

[10] Z. Li, Z. Rao, L. Pan, and Z. Xu, "Mts-mixers: Multivariate time series forecasting via factorized temporal and channel mixing," *ArXiv*, vol. abs/2302.04501, 2023.

[11] L. donghao and wang xue, "ModernTCN: A modern pure convolution structure for general time series analysis," in *The Twelfth International Conference on Learning Representations*, 2024. [Online]. Available: https://openreview.net/forum?id=vpJMJerXHU

[12] H. Wu, T. Hu, Y. Liu, H. Zhou, J. Wang, and M. Long, "Timesnet: Temporal 2d-variation modeling for general time series analysis," in *International Conference on Learning Representations*, 2023.

[13] S.-A. Chen, C.-L. Li, S. O. Arik, N. C. Yoder, and T. Pfister, "Tsmixer: An all-mlp architecture for time series forecasting," *Transactions on Machine Learning Research*, 2023. [Online]. Available: https://openreview.net/forum?id=wbpxTuXgm0

[14] T. Zhang, Y. Zhang, W. Cao, J. Bian, X. Yi, S. Zheng, and J. Li, "Less is more: Fast multivariate time series forecasting with light sampling-oriented mlp structures," 2022. [Online]. Available: https://arxiv.org/abs/2207.01186

[15] X. S. T. H. H. L. L. M. J. Y. Z. Shiyu Wang, Haixu Wu and J. Zhou, "Timemixer: Decomposable multiscale mixing for time series forecasting," in *International Conference on Learning Representations (ICLR)*, 2024. [Online]. Available: https://arxiv.org/abs/2405.14616

[16] C. Li, B. Xiao, and Q. Yuan, "Unettsf: A better performance linear complexity time series prediction model," 2024. [Online]. Available: https://arxiv.org/abs/2401.03001

[17] H. Wang, J. Peng, F. Huang, J. Wang, J. Chen, and Y. Xiao, "Micn: Multi-scale local and global context modeling for long-term series forecasting," 2023.