Article

Forecasting the CO2 Emissions at the Global Level: A Multilayer Artificial Neural Network Modelling – Supplementary Materials

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Table S1. Simulation results based on different combination of hidden layer and neuron.

ANN structure	Name of country	Training time (in sec)	Testing time (in sec)	MSE in training	MAPE value during testing(%)
1hidden 5 neurons		6.138478	0.009161	2.3232e-04	4.0062
1hidden 6neurons		6.216188	0.009189	3.5767e-04	5.3370
1hidden 7neurons		6.123864	0.009349	2.9401e-04	4.2950
1hidden 8 neurons		6.269911	0.008752	3.0132e-04	4.1285
1 hidden 9 neurons		10.028355	0.010354	3.5327e-04	3.5209
2hidden 7 and 2neurons	India	9.831674	0.009441	3.4736e-04	4.1261
2hidden 8 and 3 neurons		10.636431	0.009528	3.4793e-04	3.8685
2hidden 9 an 3neurons		9.585224	0.009823	3.1842e-04	**2.9287**
2hidden 9 and 4neurons		9.871772	0.010052	2.0343e-04	3.1180
1hidden 5 neurons		6.110742	0.009158	4.5298e-04	2.5947
1hidden 6neurons		6.089258	0.009196	5.7419e-04	3.4048
1hidden 7neurons		6.322200	0.009140	6.7688e-04	3.6029
1hidden 8 neurons		6.152000	0.008976	5.0920e-04	3.1887
1 hidden 9 neurons		6.229867	0.009011	4.8202e-04	3.7016
2hidden 7 and 2neurons	China	9.389856	0.010075	4.3010e-04	1.9431
2hidden 8 and 3 neurons		10.057381	0.009753	3.0071e-04	1.9622
2hidden 9 an 3neurons		9.766929	0.009766	3.9001e-04	**1.7896**
2hidden 9 and 4neurons		9.975999	0.009455	4.2449e-04	2.9416
1hidden 5 neurons	Iran	6.913849	0.009312	5.7841e-04	4.6391
1hidden 6neurons		6.887546	0.009127	7.1798e-04	4.3433

1hidden 7neurons		7.074856	0.012755	7.9437e-04	4.3276
1hidden 8 neurons		7.192900	0.009457	5.7418e-04	4.6925
1 hidden 9 neurons		7.899810	0.012146	7.8194e-04	4.5488
2hidden 7 and 2neurons		9.371471	0.010794	4.0064e-04	2.9805
2hidden 8 and 3 neurons		9.362102	0.009566	6.9403e-04	2.9686
2hidden 9 an 3neurons		9.417953	0.009692	4.1715e-04	**2.3610**
2hidden 9 and 4neurons		9.448383	0.009704	6.3174e-04	3.4062
1hidden 5 neurons		5.754868	0.008696	4.9800e-04	4.7633
1hidden 6neurons		5.861521	0.008901	6.7324e-04	3.4051
1hidden 7neurons		5.823516	0.008789	4.4774e-04	4.9455
1hidden 8 neurons		5.971879	0.008950	3.6985e-04	4.5893
1 hidden 9 neurons		6.232529	0.008714	4.4659e-04	5.4749
2hidden 7 and 2neurons	South Korea	7.720223	0.009725	4.7267e-04	4.0795
2hidden 8 and 3 neurons		9.150815	0.009356	3.3289e-04	2.7722
2hidden 9 an 3neurons		9.241007	0.009807	6.5473e-04	**2.4803**
2hidden 9 and 4neurons		9.401891	0.010197	4.4097e-04	3.3424
1hidden 5 neurons		5.868935	0.008757	0.0011	3.8649
1hidden 6neurons		5.918079	0.009310	0.0011	3.2082
1hidden 7neurons		6.007617	0.009096	0.0011	3.9209
1hidden 8 neurons		5.918384	0.008888	0.0011	3.9862
1 hidden 9 neurons		5.953414	0.008799	0.0014	3.9108
2hidden 7 and 2neurons	Canada	7.749690	0.009708	6.0841e-04	4.3843
2hidden 8 and 3 neurons		7.810109	0.009941	0.0011	3.7945
2hidden 9 an 3neurons		8.126898	0.009525	7.2345e-04	**2.9358**
2hidden 9 and 4neurons		7.769944	0.009471	0.0012	3.9124
1hidden 5 neurons		5.935187	0.009459	0.0012	9.7618
1hidden 6neurons		5.890987	0.008772	9.3132e-04	9.8918
1hidden 7neurons		6.029074	0.009080	0.0019	10.5051
1hidden 8 neurons		5.919254	0.011954	0.0023	10.3466
1 hidden 9 neurons		5.993429	0.008863	5.1598e-04	10.8022
2hidden 7 and 2neurons	Indonesia	11.321229	0.009985	0.0020	9.8449
2hidden 8 and 3 neurons		8.231340	0.009959	0.0013	9.8369
2hidden 9 an 3neurons		11.567121	0.015924	3.6109e-04	**9.6898**
2hidden 9 and 4neurons		11.907859	0.009690	7.9649e-04	9.9591

1hidden 5 neurons		5.963350	0.009413	0.0012	6.4509
1hidden 6neurons		5.937830	0.009012	0.0015	6.4964
1hidden 7neurons		5.991229	0.009164	0.0012	6.0184
1hidden 8 neurons		6.132805	0.009207	0.0011	6.2771
1 hidden 9 neurons		6.088682	0.009066	0.0012	6.3698
2hidden 7 and 2neurons	Brazil	11.303435	0.009937	7.5015e-04	6.0302
2hidden 8 and 3 neurons		9.845643	0.009931	0.0014	6.1265
2hidden 9 an 3neurons		10.382500	0.010050	9.2622e-04	**5.3345**
2hidden 9 and 4neurons		11.795995	0.01019	0.0012	6.1943
1hidden 5 neurons		5.850833	0.009198	0.0015	2.9419
1hidden 6neurons		5.919399	0.009238	0.0012	2.8948
1hidden 7neurons		5.884500	0.009034	0.0011	2.8201
1hidden 8 neurons		6.110328	0.009050	0.0015	3.4969
1 hidden 9 neurons		6.018903	0.008584	0.0017	3.5420
2hidden 7 and 2neurons	South Africa	8.343964	0.009915	6.9560e-04	2.9090
2hidden 8 and 3 neurons		10.166757	0.009720	0.0011	2.8282
2hidden 9 an 3neurons		9.733629	0.009733	6.1091e-04	**2.7524**
2hidden 9 and 4neurons		9.618706	0.009444	9.5343e-04	2.7581
1hidden 5 neurons		5.858096	0.009000	0.0014	3.6678
1hidden 6neurons		5.888978	0.009337	7.0457e-04	2.3329
1hidden 7neurons		5.943035	0.008922	0.0011	2.5249
1hidden 8 neurons		5.925326	0.009325	6.9130e-04	2.1518
1 hidden 9 neurons		6.064403	0.008917	9.5070e-04	4.4129
2hidden 7 and 2neurons	Mexico	9.329162	0.009422	5.5520e-04	2.0929
2hidden 8 and 3 neurons		9.155506	0.009456	4.5116e-04	2.0402
2hidden 9 an 3neurons		9.758929	0.009660	1.6016e-04	**1.9266**
2hidden 9 and 4neurons		9.605513	0.012369	8.4504e-04	2.5691
1hidden 5 neurons		6.054959	0.008867	2.4340e-04	2.9384
1hidden 6neurons		6.178992	0.009523	3.0232e-04	2.3227
1hidden 7neurons		5.896868	0.008963	1.1582e-04	2.3548
1hidden 8 neurons		5.935108	0.009247	2.7431e-04	3.3400
1 hidden 9 neurons	Turkey	6.066213	0.009055	3.7015e-04	2.3665
2hidden 7 and 2neurons		9.323097	0.009191	2.7164e-04	2.2197
2hidden 8 and 3 neurons		9.258260	0.009341	1.5396e-04	2.8701
2hidden 9 an 3neurons		9.335503	0.009375	1.5836e-04	**2.1538**

2hidden 9 and 4neurons		9.484636	0.009525	1.7254e-04	2.8923
1hidden 5 neurons		5.912477	0.009287	4.0076e-04	3.8219
1hidden 6neurons		5.898434	0.009094	6.5776e-04	3.8112
1hidden 7neurons		6.059746	0.009049	5.9981e-04	3.6756
1hidden 8 neurons		6.188681	0.009060	6.6862e-04	3.6976
1 hidden 9 neurons		6.863421	0.009375	6.4721e-04	3.6512
2hidden 7 and 2neurons	Australia	9.219789	0.009911	5.0460e-04	3.6453
2hidden 8 and 3 neurons		9.232531	0.009762	4.5971e-04	3.7155
2hidden 9 an 3neurons		9.363223	0.009914	5.5587e-04	**3.4001**
2hidden 9 and 4neurons		9.319407	0.009774	5.7673e-04	3.4514

Table S2. Data division during training phase for Group-1 countries.

Sl. No.	Name of country	Ratio of data division	MAPE(in %)	RMSE	MAE
1	India	80-20%	2.9287	0.0198	0.0235
		70-30%	3.5062	0.0253	0.0214
		60-40%	5.0285	0.0345	0.0284
2	China	80-20%	1.7896	0.0113	0.0150
		70-30%	5.3518	0.0350	0.0288
		60-40%	4.9046	0.0310	0.0263
3	Iran	80-20%	2.3610	0.0262	0.0277
		70-30%	5.2414	0.0464	0.0399
		60-40%	4.5314	0.0359	0.0302
4	South Korea	80-20%	2.4803	0.0244	0.0324
		70-30%	4.0628	0.0422	0.0330
		60-40%	4.3806	0.0400	0.0330
5	Canada	80-20%	2.9358	0.0244	0.0277
		70-30%	3.5630	0.0433	0.0344
		60-40%	4.0554	0.0423	0.0366
6	Indonesia	80-20%	9.6898	0.0767	0.1077
		70-30%	7.4279	0.0852	0.0598
		60-40%	6.9903	0.0838	0.0463
7	USA	80-20%	2.7168	0.0265	0.0308
		70-30%	5.3612	0.0574	0.0490
		60-40%	5.3558	0.0537	0.0507
8	Japan	80-20%	3.5206	0.0214	0.0264
		70-30%	2.5840	0.0298	0.0244
		60-40%	3.0422	0.0349	0.0293
9	Saudi Arabia	80-20%	5.9153	0.0462	0.0535
		70-30%	6.4128	0.0550	0.0587
		60-40%	10.1447	0.0688	0.0549

Table S3. Data division during training phase for Group-2 countries.

Sl. No.	Name of country	Ratio of data division	MAPE(in %)	RMSE	MAE
1	Brazil	80-20%	5.3345	0.0330	0.0412
		70-30%	5.3642	0.0494	0.0414
		60-40%	6.2348	0.0501	0.0422
2	South Africa	80-20%	2.7524	0.0279	0.0379
		70-30%	5.6019	0.0541	0.0475
		60-40%	3.6512	0.0372	0.0302
3	Mexico	80-20%	1.9266	0.0200	0.0224
		70-30%	2.5660	0.0302	0.0232
		60-40%	2.6386	0.0265	0.0227
4	Turkey	80-20%	2.1538	0.0162	0.0209
		70-30%	2.7996	0.0233	0.0205
		60-40%	2.2536	0.0217	0.0151
5	Australia	80-20%	3.4001	0.0367	0.0417
		70-30%	3.1685	0.0337	0.0292
		60-40%	4.5450	0.0422	0.0387
6	UK	80-20%	3.5419	0.0410	0.0502
		70-30%	6.4151	0.0534	0.0470
		60-40%	4.0331	0.0361	0.0304
7	Italy	80-20%	8.8015	0.0653	0.0769
		70-30%	10.4971	0.1020	0.0869
		60-40%	9.3649	0.0915	0.0820
8	France	80-20%	3.8158	0.0241	0.0333
		70-30%	5.1282	0.0425	0.0335
		60-40%	5.2287	0.0419	0.0354

Table 4. MAPE values for Group-I and Group-II countries using SVM with different kernels.

Name of country	SVM-Linear	SVM-RBF	SVM-Polynomial
India	4.9006	57.1999	114.7085
China	29.2176	62.5550	265.2074
Iran	36.0347	53.4743	37.3229
South Korea	9.1170	52.5174	21.9167
Canada	16.5645	17.8197	54.8594
Indonesia	9.5794	54.5980	65.2664
USA	14.7355	4.4472	37.3167
Saud Arab	32.6173	55.2972	21.5335
Japan	8.8881	5.3696	36.3962
Brazil	5.5486	43.3320	8.2418
South Africa	14.6854	39.4817	20.4860
Mexico	5.6213	19.2069	33.2481
Turkey	3.7920	47.7297	33.8005
Australia	12.6662	33.7529	22.9515
UK	11.9063	27.7873	241.0693
Italy	19.1438	11.9933	21.6164
France	10.1377	7.9741	35.7993