

Online Supplementary Material

Appendix A

Table A1: 2-cluster solution for CO₂ features for all methods: Model 2

Country	Cluster	Country	Cluster
14 China	2	36 Kenya	1
68 United States	3	37 Korea, Rep.	1
1 Albania	1	38 Luxembourg	1
2 Algeria	1	39 Malaysia	1
3 Argentina	1	40 Mauritius	1
4 Australia	1	41 Mexico	1
5 Austria	1	42 Mongolia	1
6 Bangladesh	1	43 Morocco	1
7 Benin	1	44 Mozambique	1
8 Bolivia	1	45 Nepal	1
9 Botswana	1	46 Netherlands	1
10 Brazil	1	47 New Zealand	1
11 Bulgaria	1	48 Norway	1
12 Cameroon	1	49 Pakistan	1
13 Chile	1	50 Panama	1
15 Colombia	1	51 Paraguay	1
16 Congo, Dem. Rep.	1	52 Peru	1
17 Congo, Rep.	1	53 Philippines	1
18 Costa Rica	1	54 Portugal	1
19 Cuba	1	55 Saudi Arabia	1
20 Cyprus	1	56 Senegal	1
21 Denmark	1	57 South Africa	1
22 Dominican Republic	1	58 Spain	1
23 Ecuador	1	59 Sri Lanka	1
24 Egypt, Arab Rep.	1	60 Sudan	1
25 Ethiopia	1	61 Sweden	1
26 Finland	1	62 Thailand	1
27 France	1	63 Togo	1
28 Greece	1	64 Trinidad and Tob	1
29 Honduras	1	65 Tunisia	1
30 India	1	66 Turkey	1
31 Indonesia	1	67 United Kingdom	1
32 Iran, Islamic Rep.	1	69 Uruguay	1
33 Italy	1	70 Venezuela, RB	1
34 Japan	1	71 Zambia	1
35 Jordan	1	72 Zimbabwe	1

Table A2: 2-cluster solution for CO₂ features for Ward and k-means methods: Model 3

Country	Cluster	Country	Cluster
1 Albania	1	39 Mauritius	1
2 Algeria	1	40 Mexico	1
3 Argentina	1	41 Mongolia	1
4 Australia	1	42 Morocco	1
5 Austria	1	43 Mozambique	1
6 Bangladesh	1	44 Nepal	1
7 Benin	1	45 Netherlands	1
8 Bolivia	1	46 New Zealand	1
9 Botswana	1	47 Norway	1
10 Brazil	1	48 Pakistan	1
11 Bulgaria	1	49 Panama	1
12 Cameroon	1	50 Paraguay	1
13 Chile	1	51 Peru	1
14 Colombia	1	52 Philippines	1
15 Congo, Dem. Rep	1	53 Portugal	1
16 Congo, Rep.	1	54 Saudi Arabia	1
17 Costa Rica	1	55 Senegal	1
18 Cuba	1	56 South Africa	1
19 Cyprus	1	57 Spain	1
20 Denmark	1	58 Sri Lanka	1
21 Dominican Reput	1	59 Sudan	1
22 Ecuador	1	60 Sweden	1
23 Egypt, Arab Rep.	1	61 Thailand	1
24 Ethiopia	1	62 Togo	1
25 Finland	1	63 Trinidad and Tobago	1
27 Greece	1	64 Tunisia	1
28 Honduras	1	65 Turkey	1
30 Indonesia	1	67 Uruguay	1
31 Iran, Islamic Rep.	1	68 Venezuela, RB	1
32 Italy	1	69 Zambia	1
34 Jordan	1	70 Zimbabwe	1
35 Kenya	1	26 France	2
36 Korea, Rep.	1	29 India	2
37 Luxembourg	1	33 Japan	2
38 Malaysia	1	66 United Kingdom	2

Table A3: 2-cluster solution for CO₂ features for all methods: Model 4

Country	Cluster	Country	Cluster
14 China	2	36 Kenya	1
68 United States	2	37 Korea, Rep.	1
1 Albania	1	38 Luxembourg	1
2 Algeria	1	39 Malaysia	1
3 Argentina	1	40 Mauritius	1
4 Australia	1	41 Mexico	1
5 Austria	1	42 Mongolia	1
6 Bangladesh	1	43 Morocco	1
7 Benin	1	44 Mozambique	1
8 Bolivia	1	45 Nepal	1
9 Botswana	1	46 Netherlands	1
10 Brazil	1	47 New Zealand	1
11 Bulgaria	1	48 Norway	1
12 Cameroon	1	49 Pakistan	1
13 Chile	1	50 Panama	1
15 Colombia	1	51 Paraguay	1
16 Congo, Dem	1	52 Peru	1
17 Congo, Rep.	1	53 Philippines	1
18 Costa Rica	1	54 Portugal	1
19 Cuba	1	55 Saudi Arabia	1
20 Cyprus	1	56 Senegal	1
21 Denmark	1	57 South Africa	1
22 Dominican R	1	58 Spain	1
23 Ecuador	1	59 Sri Lanka	1
24 Egypt, Arab I	1	60 Sudan	1
25 Ethiopia	1	61 Sweden	1
26 Finland	1	62 Thailand	1
27 France	1	63 Togo	1
28 Greece	1	64 Trinidad and	1
29 Honduras	1	65 Tunisia	1
30 India	1	66 Turkey	1
31 Indonesia	1	67 United Kingd	1
32 Iran, Islamic	1	69 Uruguay	1
33 Italy	1	70 Venezuela, F	1
34 Japan	1	71 Zambia	1
35 Jordan	1	72 Zimbabwe	1

Table A4: 2-cluster solution for CO₂ features for Ward and k-means methods: Model 5

Country	Cluster	Country	Cluster
1 Albania	1	39 Mauritius	1
2 Algeria	1	40 Mexico	1
3 Argentina	1	41 Mongolia	1
4 Australia	1	42 Morocco	1
5 Austria	1	43 Mozambique	1
6 Bangladesh	1	44 Nepal	1
7 Benin	1	45 Netherlands	1
8 Bolivia	1	46 New Zealand	1
9 Botswana	1	47 Norway	1
10 Brazil	1	48 Pakistan	1
11 Bulgaria	1	49 Panama	1
12 Cameroon	1	50 Paraguay	1
13 Chile	1	51 Peru	1
14 Colombia	1	52 Philippines	1
15 Congo, Dem. Rep.	1	53 Portugal	1
16 Congo, Rep.	1	54 Saudi Arabia	1
17 Costa Rica	1	55 Senegal	1
18 Cuba	1	56 South Africa	1
19 Cyprus	1	57 Spain	1
20 Denmark	1	58 Sri Lanka	1
21 Dominican Republic	1	59 Sudan	1
22 Ecuador	1	60 Sweden	1
23 Egypt, Arab Rep.	1	61 Thailand	1
24 Ethiopia	1	62 Togo	1
25 Finland	1	63 Trinidad and Tobago	1
27 Greece	1	64 Tunisia	1
28 Honduras	1	65 Turkey	1
30 Indonesia	1	67 Uruguay	1
31 Iran, Islamic Rep.	1	68 Venezuela, RB	1
32 Italy	1	69 Zambia	1
34 Jordan	1	70 Zimbabwe	1
35 Kenya	1	26 France	2
36 Korea, Rep.	1	29 India	2
37 Luxembourg	1	33 Japan	2
38 Malaysia	1	66 United Kingdom	2

Table A5: Adjusted Rand Indices for compatibility of cluster solutions across the methods for CO₂ Features: Model 2

	Ward's Method	Average Linkage	Complete Linkage	k-means
2-clusters				
Average Linkage	1.00			
Complete Linkage	1.00	1.00		
k-means	1.00	1.00	1.00	
k-medoids	1.00	1.00	1.00	1.00
3-clusters				
Average Linkage	1.00			
Complete Linkage	1.00	1.00		
k-means	1.00	1.00	1.00	
k-medoids	1.00	1.00	1.00	1.00

Table A6: Adjusted Rand Indices for compatibility of cluster solutions for coefficients of all significant variables: Model 2

	Ward's Method	Average Linkage	Complete Linkage	k-means
2-clusters				
Average Linkage	0.370			
Complete Linkage	0.370	1.000		
k-means	0.687	0.370	0.370	
k-medoids	0.684	0.513	0.513	0.783

Table A7: Adjusted Rand Indices for compatibility of cluster solutions across the methods for CO₂ Features: Model 3

	Ward's Method	Average Linkage	Complete Linkage	k-means
2-clusters				
Average Linkage	0.368			
Complete Linkage	0.368	1.000		
k-means	1.000	0.368	0.368	
k-medoids	0.836	0.474	0.474	0.836

Table A8: Adjusted Rand Indices for compatibility of cluster solutions for coefficients of all significant variables: Model 3

	Ward's Method	Average Linkage	Complete Linkage	k-means
2-clusters				
Average Linkage	0.515			
Complete Linkage	0.419	0.857		
k-means	0.630	0.402	0.321	
k-medoids	0.680	0.305	0.239	0.833

Table A9: Adjusted Rand Indices for compatibility of cluster solutions for CO₂ features: Model 4

	Ward's Method	Average Linkage	Complete Linkage	k-means
2-clusters				
Average Linkage	1			
Complete Linkage	1	1		
k-means	1	1	1	
k-medoids	1	1	1	1
3-clusters				
Average Linkage	0.328			
Complete Linkage	0.328	1.000		
k-means	1.000	0.328	0.328	
k-medoids	0.328	1.000	1.000	0.328

Table A10: Adjusted Rand Indices for compatibility of cluster solutions for coefficients of all significant variables: Model 4

	Ward's Method	Average Linkage	Complete Linkage	k-means
2-clusters				
Average Linkage	0.381			
Complete Linkage	0.831	0.488		
k-means	0.732	0.349	0.780	
k-medoids	0.626	0.573	0.771	0.677

Table A11: Adjusted Rand Indices for compatibility of cluster solutions across the methods for CO₂ Features: Model 5

	Ward's Method	Average Linkage	Complete Linkage	k-means
2-clusters				
Average Linkage	0.633			
Complete Linkage	1.000	0.633		
k-means	1.000	0.633	1.000	
k-medoids	0.316	0.163	0.316	0.316
3-clusters				
Average Linkage	0.254			
Complete Linkage	0.476	0.641		
k-means	0.818	0.197	0.381	
k-medoids	0.476	0.641	1.000	0.381

Table A12: Adjusted Rand Indices for compatibility of cluster solutions for coefficients of all significant variables: Model 5

	Ward's Method	Average Linkage	Complete Linkage	k-means
2- clusters				
Average Linkage	0.053			
Complete Linkage	0.427	0.178		
k-means	0.718	0.047	0.392	
k-Medoids	-0.054	-0.017	-0.084	-0.036

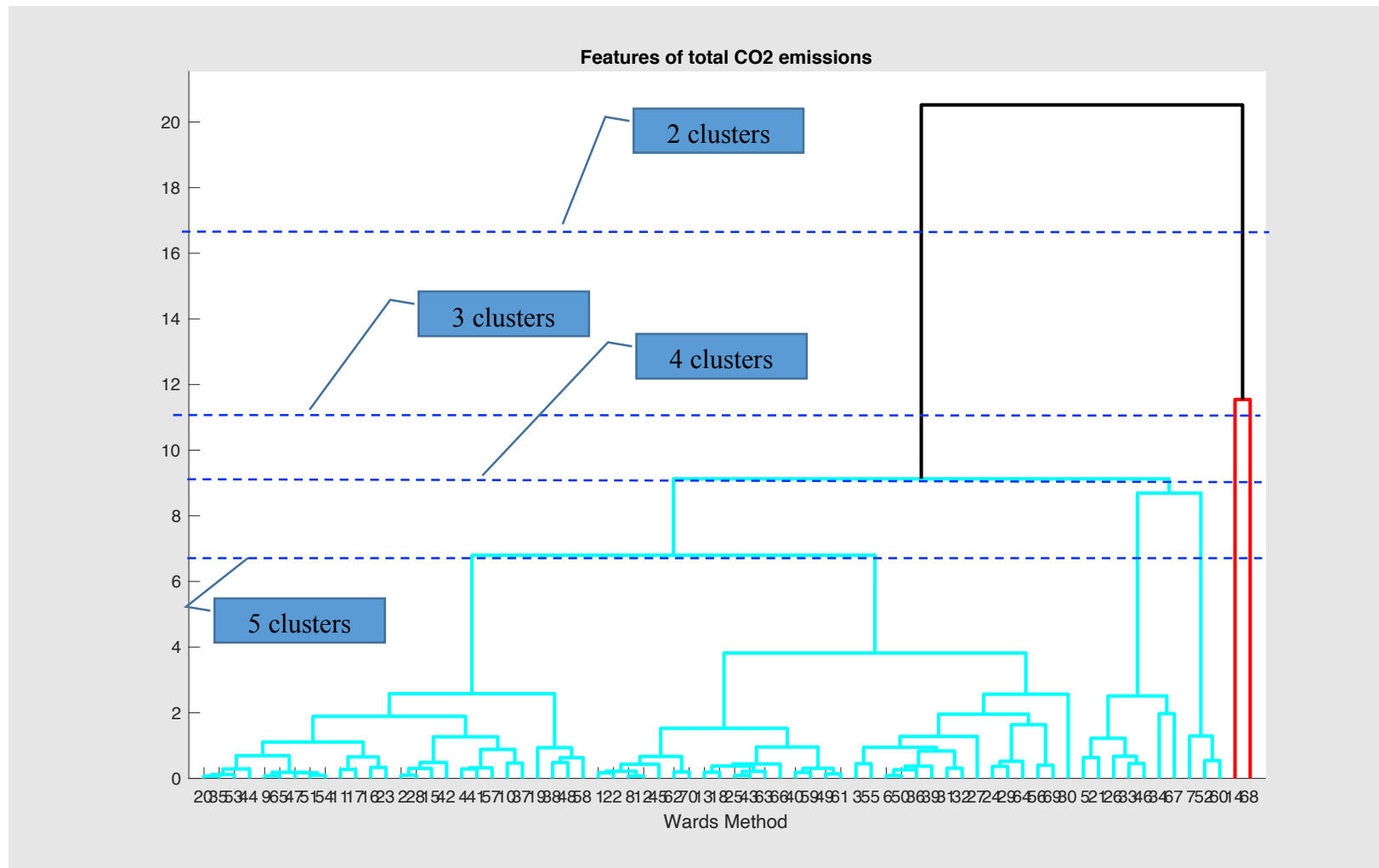


Figure A1: Cluster solutions of the features of CO2 emissions: Model 2

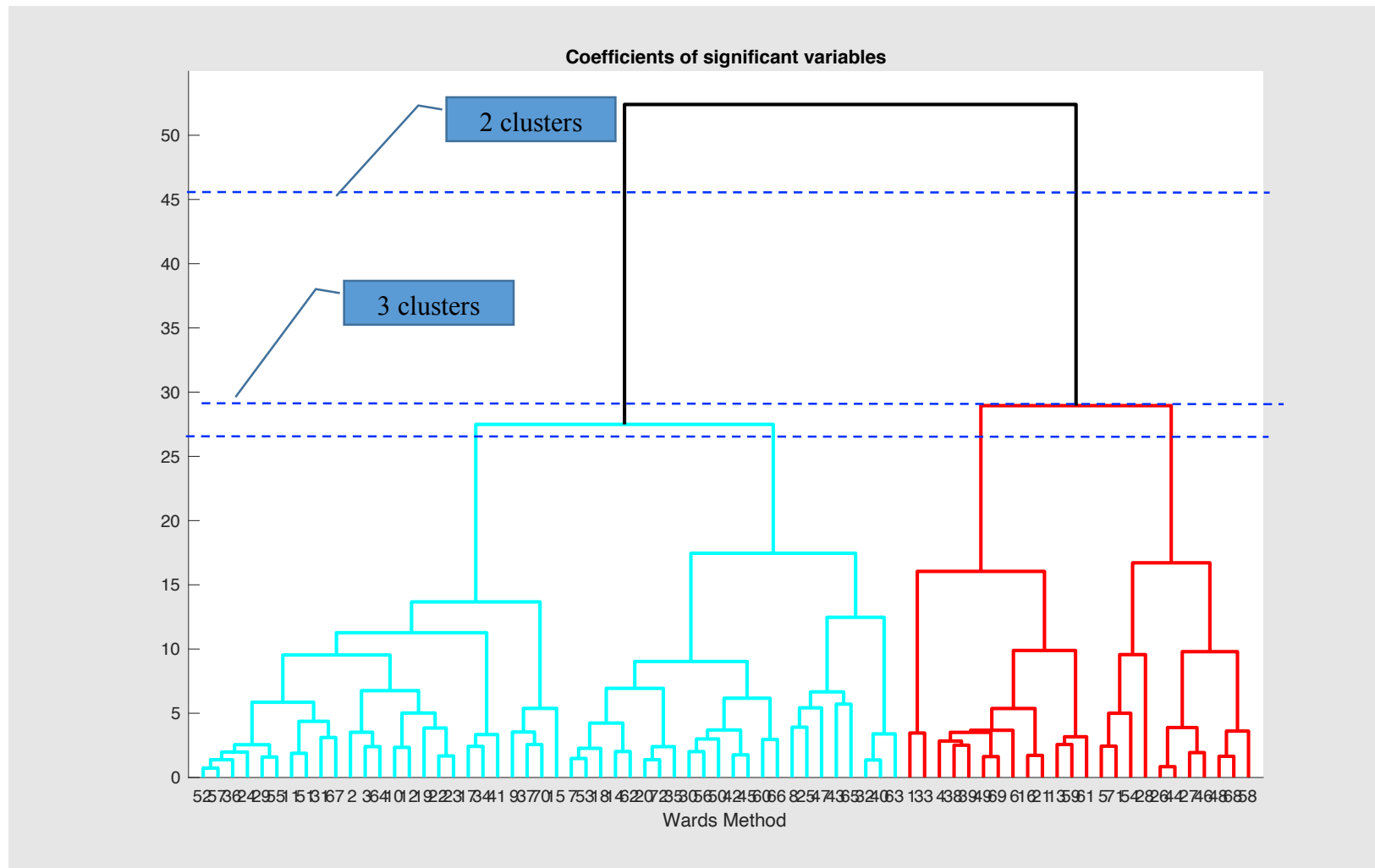


Figure A2: Cluster Solutions of the impact of all significant explanatory variables on CO2 emissions: NRENIT, POP, RGDP, CO2 Lag: Model 2

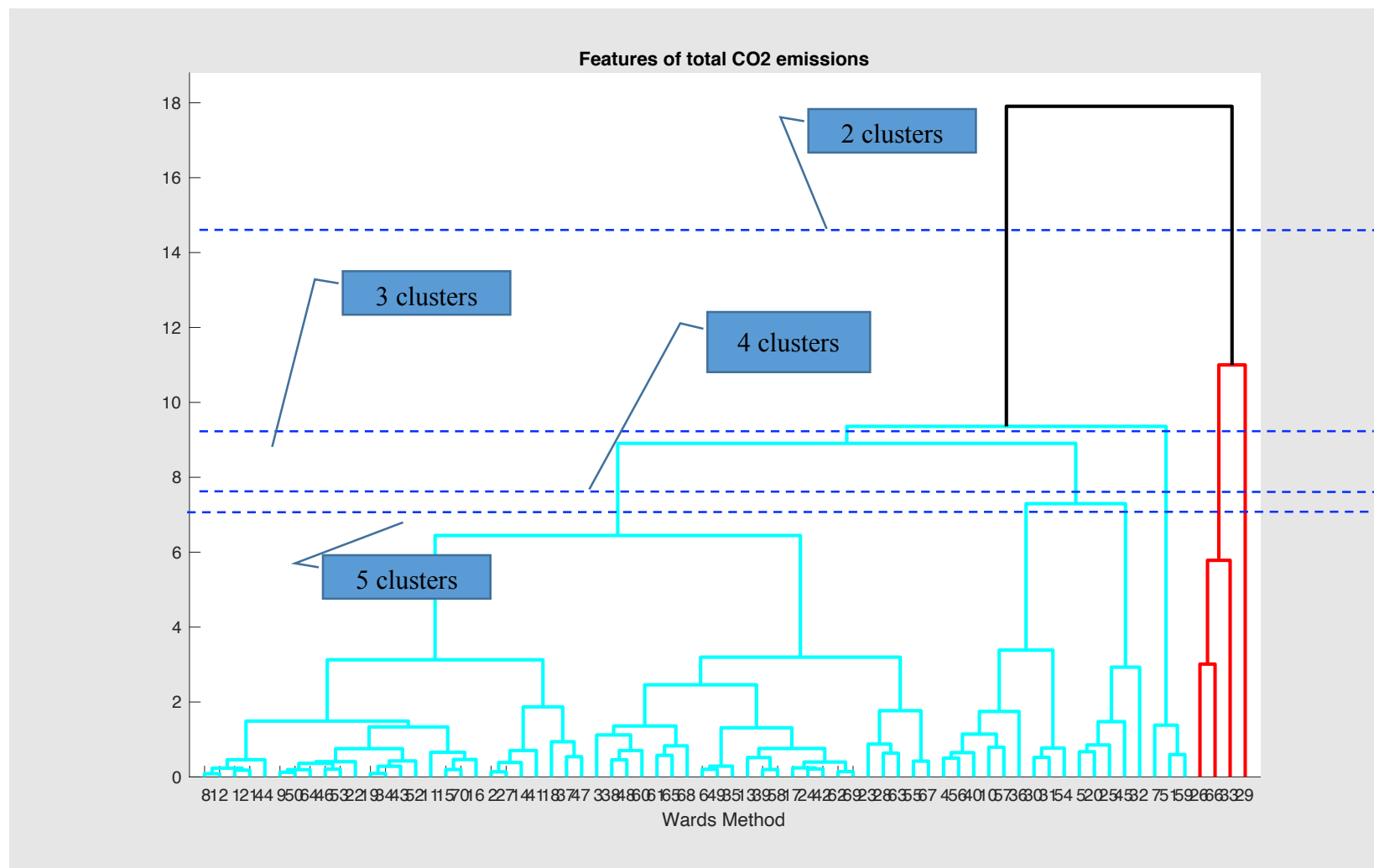


Figure A3: Cluster solutions of the features of CO2 emissions: Model 3

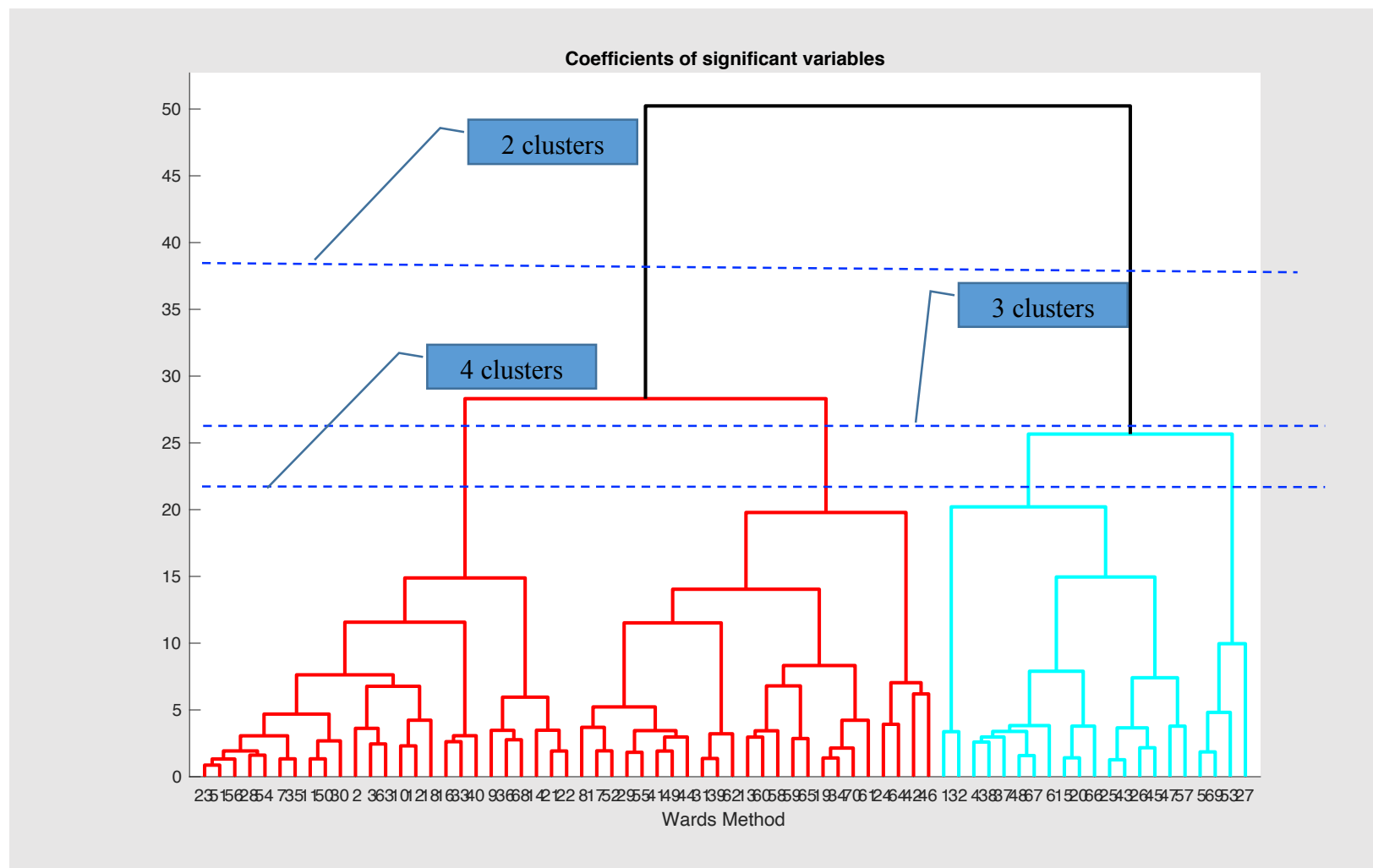


Figure A4: Cluster Solutions of the impact of all significant explanatory variables on CO2 emissions: NRENIT, POP, RGDP, CO2 Lag: Model 3

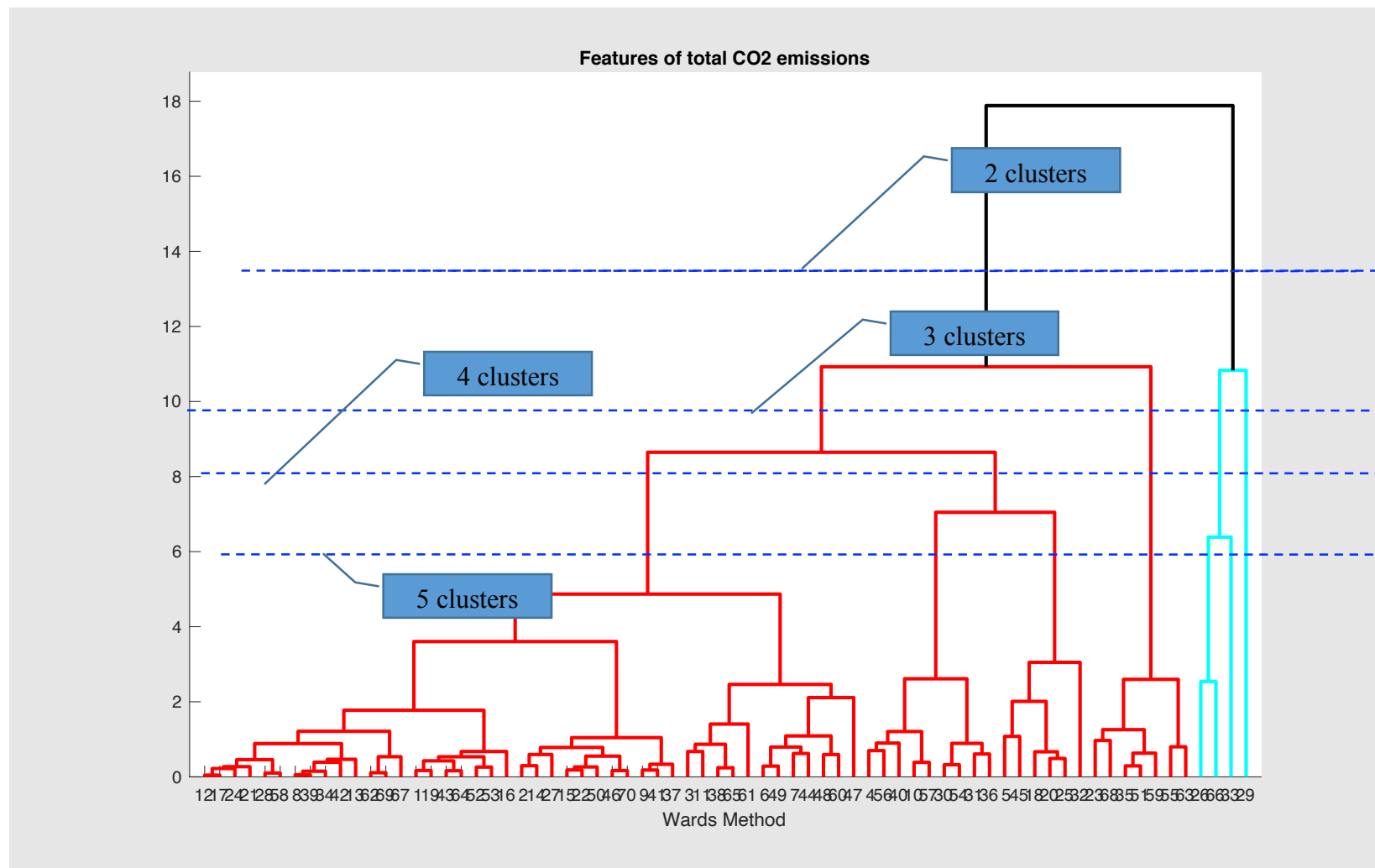


Figure A5: Cluster solutions of the features of CO2 emissions: Model 4

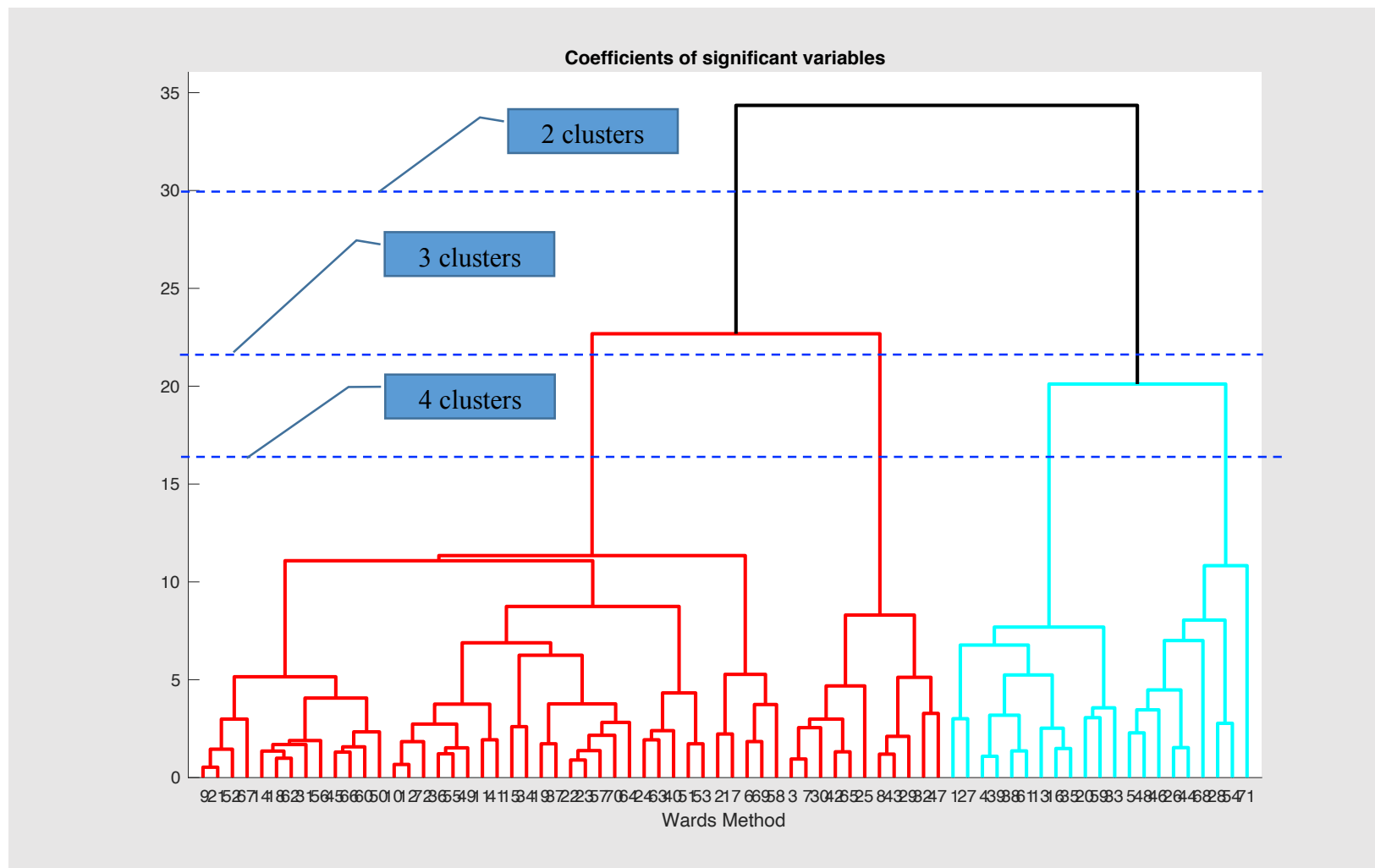


Figure A6: Cluster Solutions of the impact of all significant explanatory variables on CO2 emissions: NRENIT, POP, RGDP, CO2 Lag: Model 4

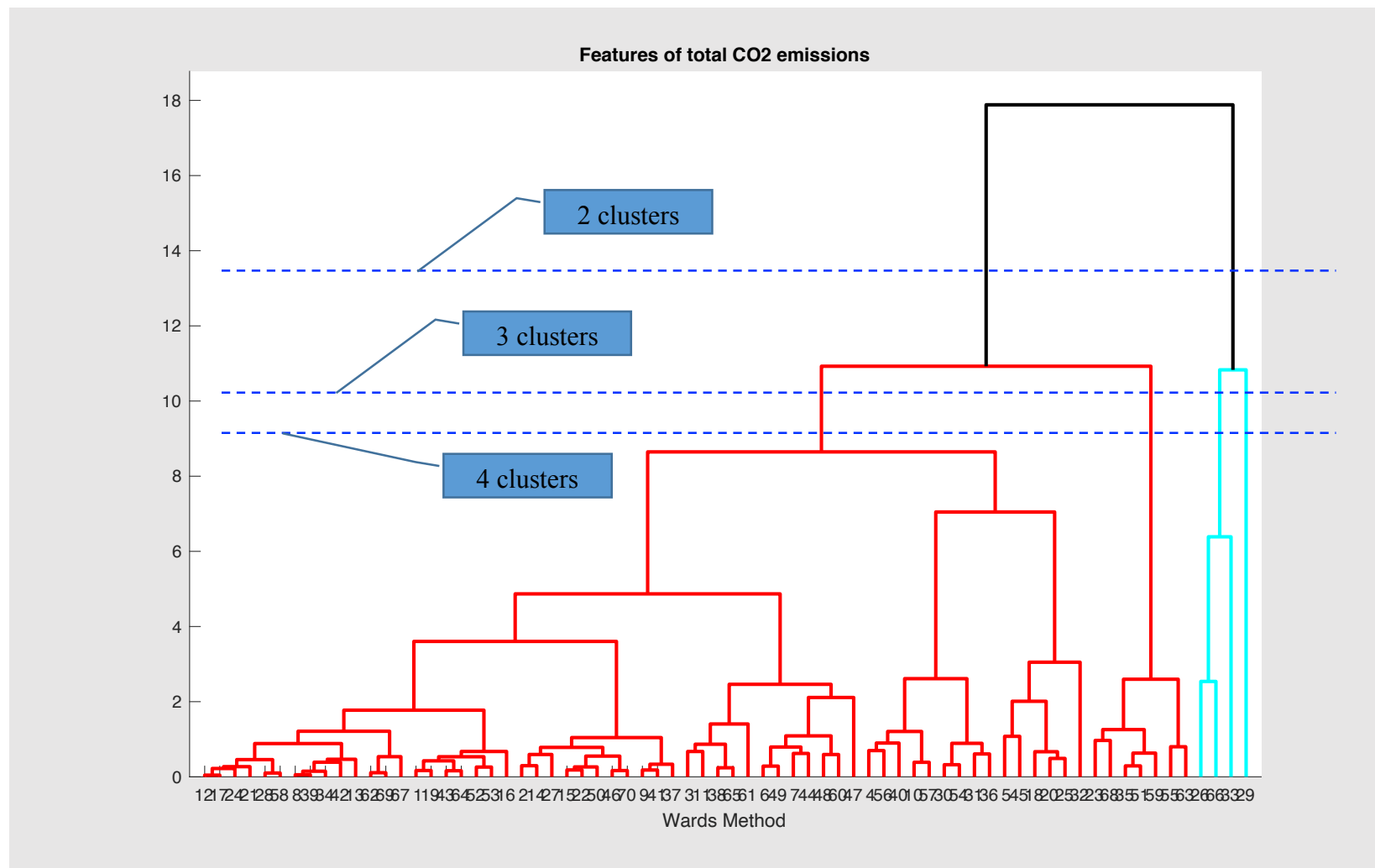


Figure A7: Cluster solutions of the features of CO2 emissions: Model 5

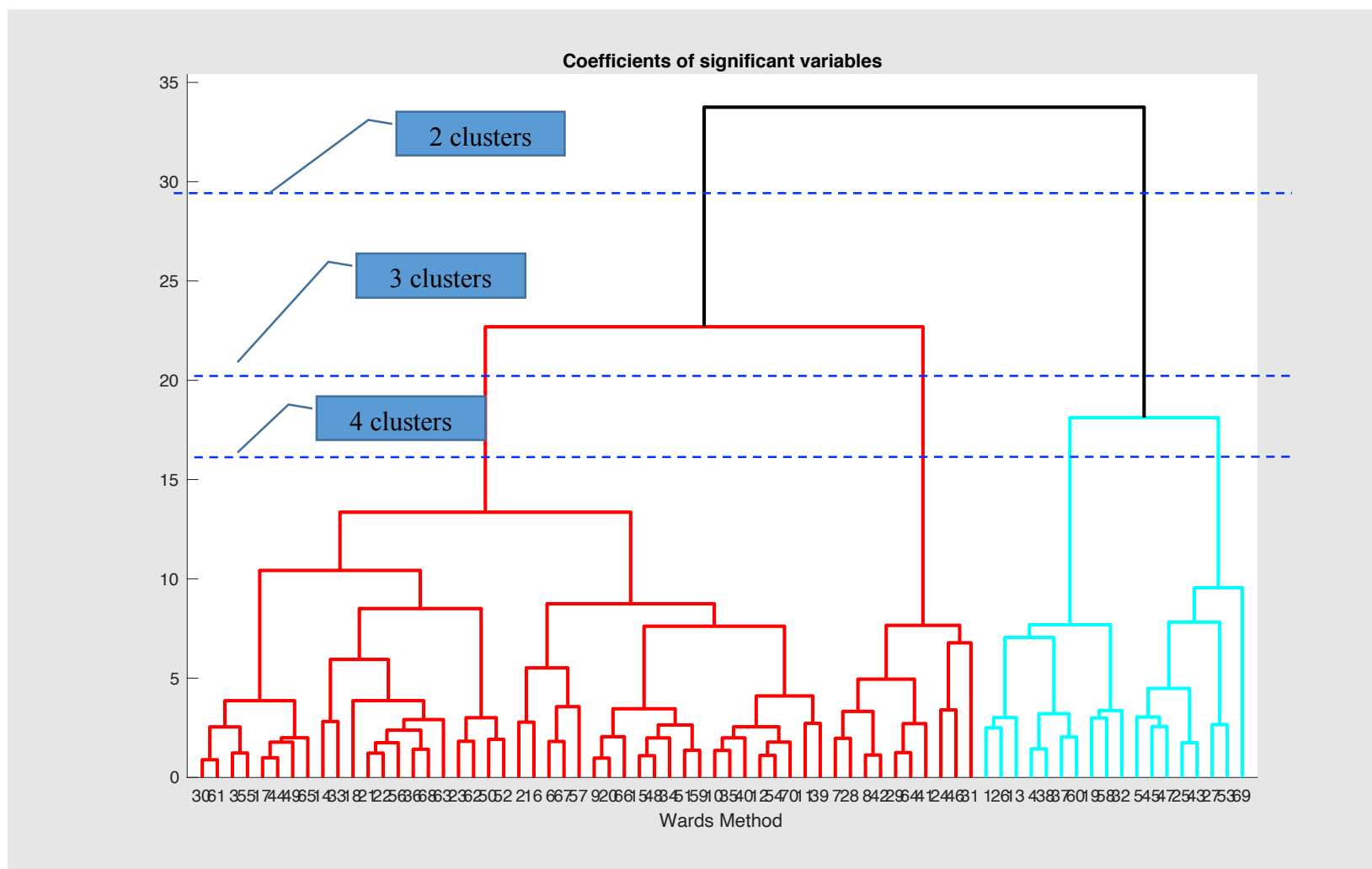


Figure A8 Cluster Solutions of the impact of all significant explanatory variables on CO2 emissions: NRENIT, POP, RGDP, CO2 Lag: Model 5

Appendix B

Table B1: Summary Statistics for the 72 Countries

Variable	Obs	Mean	Std. Dev.	Min	Max	Total
Services (value added)	2881	53.760	12.332	15.898	88.538	154881.170
Industry(value added)	2918	119	340	0.978	4090	347500
Urban population (% of total)	3312	54.691	22.679	3.956	95.311	181138.100
CO ₂ emissions	3044	196197	692948	22	9019518	597200000
Combustible renewables and waste (%)	2715	26.358	29.037	0.000	98.186	71562.760
Fossil fuel energy consumption	2702	66.110	28.425	1.654	99.997	178629.340
Real GDP per capita	3151	11068.400	15733.020	130.142	110001.100	34876543
Total Population	3312	56200000	166000000	313970	1370000000	18620000000

Real GDP per capita is measured in constant 2010 US dollar; Urban population is measured as a share of total population; Services (value added) is measured as a percentage of GDP; and Industry (value added) is measured in constant (billion) US dollar. Renewable (combustibles) and non-renewable (fossil fuel) energy intensity measures are in kg of oil equivalent per gdp (in US dollar). Urban population is measured as a % of total population.

Table B2 Summary Statistics on CO₂ emissions for the 72 countries

Country	N	Mean	SD	Minimum	Maximum
Albania	43	4617.947	2163.186	1752.826	8984.150
Algeria	43	60846.450	37519.760	5427.160	121755.400
Argentina	42	110827.900	38606.710	48815.100	191578.800
Australia	42	243203.100	89058.250	88202.350	382464.400
Austria	42	55697.020	10622.350	30821.130	74278.750
Bangladesh	34	23416.920	16827.490	3509.319	57069.520
Benin	42	1315.405	1510.293	113.677	5152.135
Bolivia	42	6974.459	4575.905	1004.758	16120.130
Botswana	33	2507.339	1668.271	22.002	5232.809
Brazil	44	213467.600	106321.400	46908.260	419754.200
Bulgaria	42	59678.770	17942.190	22295.360	91528.320
Cameroon	42	2924.171	2259.750	271.358	7638.361
Chile	43	36398.130	18601.360	13490.890	79408.880
China	42	2584401.000	2144983.000	433234.000	9019518.000
Colombia	44	46097.520	16102.610	16409.830	72423.250

Congo Dem. Rep.	43	2973.511	723.788	1646.483	4393.066
Congo, Rep.	42	982.494	570.506	223.687	2247.871
Costa	43	3433.591	2397.246	491.378	8327.757
Cuba	43	26607.240	6935.529	12181.770	38360.490
Cyprus	42	4042.518	2351.440	865.412	8188.411
Denmark	42	52707.890	8638.050	29779.710	72181.230
Dominican	44	9754.887	7058.798	1030.427	21888.320
Ecuador	44	16595.430	10606.810	1565.809	35727.580
Egypt	42	75992.290	59143.770	17088.220	220790.100
Ethiopia	42	2968.436	2013.293	341.031	7543.019
Finland	43	47278.550	13428.360	14939.360	69130.280
France	42	397819.000	61785.990	271218.700	529155.400
Greece	44	58819.680	29786.820	9405.855	98675.300
Honduras	43	3112.857	2527.881	616.056	8778.798
India	42	721981.400	558938.200	120582.000	2074345.000
Indonesia	43	180350.300	143625.400	21404.280	563984.600
Iran	42	227196.900	169433.500	36541.650	586599.000
Italy	43	356932.500	98067.090	109357.300	473970.800
Japan	43	946407.200	285492.100	232781.200	1259329.000
Jordan	42	10041.900	7339.930	979.089	22258.690
Kenya	44	6061.884	2964.004	2467.891	13567.900
Korea	42	251561.300	189976.500	12552.140	589426.300
Luxembourg	43	10691.180	1508.687	7939.055	14169.290
Malaysia	34	84912.190	66235.010	14601.990	224589.100
Mauritius	42	1469.856	1217.575	179.683	3916.356
Mexico	43	271425.700	135500.500	63116.400	474491.500
Mongolia	42	6977.079	3130.686	1393.460	12207.440
Morocco	45	23238.190	15888.060	3080.280	56537.810
Mozambique	44	2041.852	796.461	982.756	3615.662
Nepal	44	1338.955	1197.684	80.674	3619.329

Netherlands	43	147804.700	30402.270	73505.010	181927.200
New	42	23001.690	7810.565	11543.720	34759.490
Norway	42	31927.170	9747.827	13102.190	52240.080
Pakistan	44	62361.920	48035.870	14154.620	163452.900
Panama	44	4013.698	2177.307	997.424	9666.212
Paraguay	42	2493.997	1564.086	363.033	5298.815
Peru	42	24958.390	10817.730	8173.743	57857.930
Philippines	43	44018.500	21498.640	8723.793	82012.460
Portugal	44	35296.630	18386.090	9090.493	65309.270
Saudi	43	203949.800	142960.800	2676.910	533093.800
Senegal	41	3099.688	1691.538	491.378	7858.381
South	42	267322.900	109610.000	97934.570	477806.400
Spain	43	206286.500	87967.110	48928.780	358236.600
Sri	43	5976.698	3915.263	2258.872	15232.720
Sudan	43	5535.209	3743.148	1360.457	16578.510
Sweden	43	62317.680	13872.880	43743.640	92379.060
Thailand	42	100267.600	94474.310	3714.671	279403.400
Togo	42	801.501	543.335	66.006	2097.524
Trinidad	42	19863.090	13894.380	1309.119	50916.290
Tunisia	43	12945.700	7930.745	1727.157	26743.430
Turkey	42	124153.100	80244.310	16820.530	298002.400
United	43	571029.400	46726.940	448235.800	660034.300
United	43	4684786.000	818246.700	2880506.000	5794923.000
Uruguay	44	5220.141	1099.640	3179.289	8280.086
Venezuela	43	105662.600	46067.520	51928.390	192103.100
Zambia	39	2946.670	863.277	1807.831	4792.769
Zimbabwe	40	11344.320	3587.696	4473.740	17645.600

N=the number of observation and SD= the standard deviation