Supplemental Material

Forest area, CO2 emission, and COVID-19 case-fatality rate: a worldwide ecological study using spatial regression analysis

Hansen Li, Guodong Zhang, Yang Cao

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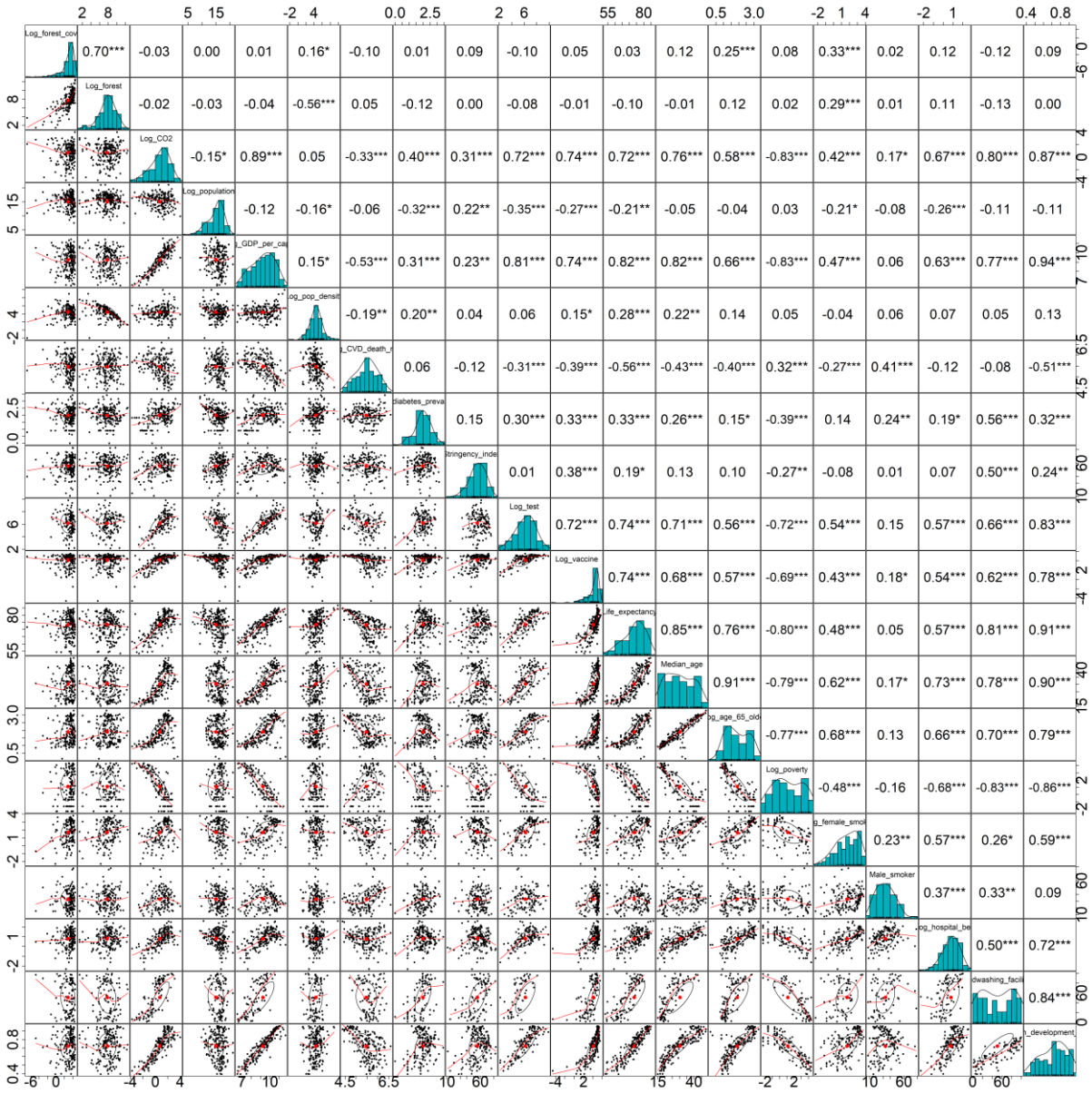

Figure S1. Pairwise scatter plots and Pearson's correlation coefficients of the independent variables. *P<0.05, **P<0.01, ***P<0.001.

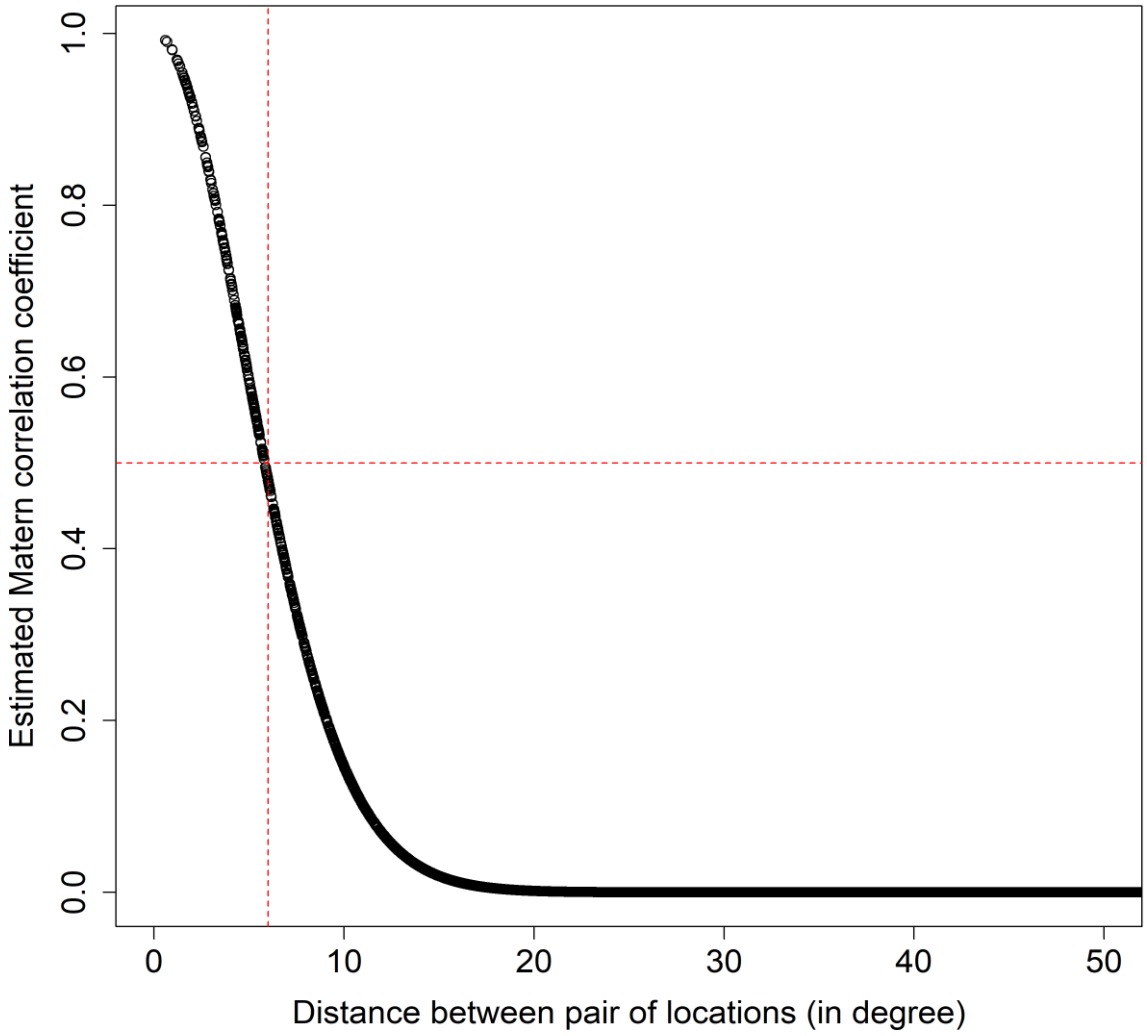

Figure S2. Strength and decay of the spatial autocorrelation between pair of locations.

Table S1. Changes in COVID-19 CFR (‰) per 10% increase in the ecological and socioeconomic variables (including forest area per capita instead of forest cover)

Variables	All countries (N=186)		Low-income countries (N=26)		Lower-middle-income countries (N=50)		Upper-middle-income countries (N=51)		High-income countries (N=59)	
	CFR change (95% CI)	*p*-value	CFR change (95% CI)	*p*-value	CFR change (95% CI)	*p*-value	CFR change (95% CI)	*p*-value	CFR change (95% CI)	*p*-value
Forest area per capita	-0.05 (-0.25, 0.15)	0.617	**-1.89 (-2.38, -1.41)**	**<0.001**	-0.16 (-0.44, 0.13)	0.318	0.22 (-0.15, 0.59)	0.264	0.02 (-0.05, 0.09)	0.514
CO_2 emission per capita	-0.25 (-0.64, 0.13)	0.218	0.70 (-0.05, 1.45)	0.196	**-0.69 (-1.21, -0.17)**	**0.022**	0.18 (-0.79, 1.15)	0.616	-0.14 (-0.34, 0.06)	0.254
Population	0.03 (-0.13, 0.20)	0.662	0.44 (-0.07, 0.96)	0.337	**0.25 (0.01, 0.49)**	**0.009**	0.14 (-0.17, 0.45)	0.400	0.04 (-0.03, 0.10)	0.316
Population density	-0.14 (-0.41, 0.13)	0.336	**-4.33 (-5.45, -3.22)**	**0.002**	-0.21 (-0.62, 0.19)	0.342	0.05 (-0.46, 0.56)	0.666	0.04 (-0.05, 0.14)	0.387
Life expectancy	**0.12 (0.04, 0.21)**	**0.004**	**0.72 (0.56, 0.87)**	**<0.001**	0.07 (-0.02, 0.16)	0.190	0.10 (-0.04, 0.23)	0.182	0.02 (-0.04, 0.08)	0.403
Male smoker	-0.01 (-0.03, 0.02)	0.457	**0.02 (-0.06, 0.1)**	**0.034**	0.00 (-0.02, 0.02)	0.519	0.00 (-0.05, 0.04)	0.586	-0.01 (-0.03, 0.01)	0.223
Female smoker	0.18 (-0.08, 0.45)	0.309	**2.18 (1.76, 2.61)**	**0.008**	0.16 (-0.24, 0.55)	0.507	0.04 (-0.38, 0.45)	0.570	**0.39 (0.20, 0.57)**	**0.001**
CVD death rate	**1.14 (0.20, 2.08)**	**0.037**	-3.55 (-6.34, -0.77)	0.167	-0.53 (-1.71, 0.64)	0.409	-0.65 (-2.02, 0.71)	0.405	**1.01 (0.54, 1.49)**	**<0.001**
Diabetes prevalence	0.26 (-0.37, 0.90)	0.448	-1.29 (-2.26, -0.33)	0.101	-0.09 (-0.60, 0.42)	0.548	-0.38 (-1.90, 1.14)	0.638	0.27 (-0.09, 0.63)	0.190
Hospital beds	-0.10 (-0.58, 0.38)	0.584	**3.87 (2.73, 5.01)**	**0.008**	-0.24 (-0.82, 0.35)	0.478	0.03 (-0.99, 1.05)	0.756	0.18 (-0.10, 0.47)	0.292
Stringency index	-0.01 (-0.04, 0.01)	0.365	-0.01 (-0.05, 0.03)	0.103	**0.02 (0.00, 0.04)**	**0.041**	-0.01 (-0.05, 0.04)	0.560	**0.05 (0.03, 0.06)**	**<0.001**
Tests	**-0.80 (-1.09, -0.50)**	**<0.001**	-0.71 (-1.54, 0.11)	0.190	-0.08 (-0.46, 0.30)	0.474	**-0.95 (-1.54, -0.36)**	**0.007**	**-0.35 (-0.47, -0.22)**	**<0.001**
Vaccinations	0.21 (-0.09, 0.52)	0.203	-0.32 (-0.76, 0.12)	0.150	0.07 (-0.32, 0.46)	0.735	-0.58 (-1.40, 0.24)	0.197	-0.09 (-0.71, 0.52)	0.624

CFR, case fatality rate; CI, confidence interval; CVD, cardiovascular diseases

Table S2. Changes in COVID-19 CFR (‰) per 10% increase in the ecological and socioeconomic variables (including GDP per capita instead of CO_2 emission per capita)

Variables	All countries (N=186)		Low-income countries (N=26)		Lower-middle-income countries (N=50)		Upper-middle-income countries (N=51)		High-income countries (N=59)	
	CFR change (95% CI)	*p*-value	CFR change (95% CI)	*p*-value	CFR change (95% CI)	*p*-value	CFR change (95% CI)	*p*-value	CFR change (95% CI)	*p*-value
Forest coverage rate	0.05 (-0.03, 0.12)	0.321	**-2.25 (-2.92, -1.57)**	**0.007**	0.03 (-0.25, 0.3)	0.572	0.14 (-0.19, 0.47)	0.455	0.05 (-0.03, 0.12)	0.321
GDP per capita	0.01 (-0.33, 0.34)	0.729	**-4.21 (-7.09, -1.32)**	**0.020**	**-0.96 (-1.74, -0.18)**	**0.020**	-0.59 (-1.77, 0.59)	0.378	0.01 (-0.33, 0.34)	0.729
Population	0.02 (-0.04, 0.07)	0.555	1.75 (0.97, 2.52)	0.103	0.23 (-0.04, 0.5)	0.171	0.24 (-0.02, 0.5)	0.084	0.02 (-0.04, 0.07)	0.555
Population density	0.03 (-0.05, 0.11)	0.498	-0.14 (-1.1, 0.83)	0.111	-0.13 (-0.47, 0.22)	0.471	-0.27 (-0.62, 0.09)	0.199	0.03 (-0.05, 0.11)	0.498
Life expectancy	0.02 (-0.03, 0.08)	0.469	**0.67 (0.46, 0.88)**	**0.001**	0.04 (-0.07, 0.14)	0.514	0.12 (-0.01, 0.25)	0.078	0.02 (-0.03, 0.08)	0.469
Male smoker	-0.01 (-0.03, 0.00)	0.122	0.14 (0.02, 0.27)	0.100	0.00 (-0.02, 0.02)	0.455	-0.02 (-0.06, 0.03)	0.410	-0.01 (-0.03, 0)	0.122
Female smoker	**0.43 (0.25, 0.62)**	**<0.001**	**1.89 (1.41, 2.37)**	**0.025**	0.19 (-0.23, 0.62)	0.278	-0.01 (-0.39, 0.36)	0.531	**0.43 (0.25, 0.62)**	**<0.001**
CVD death rate	**1.04 (0.57, 1.52)**	**<0.001**	5.65 (2.71, 8.58)	0.061	**-1.61 (-2.67, -0.55)**	**0.043**	-0.59 (-1.91, 0.73)	0.396	**1.04 (0.57, 1.52)**	**<0.001**
Diabetes prevalence	0.31 (-0.05, 0.67)	0.126	2.04 (0.54, 3.55)	0.049	0.48 (-0.13, 1.08)	0.208	0.03 (-1.48, 1.55)	0.774	0.31 (-0.05, 0.67)	0.126
Hospital beds	0.11 (-0.18, 0.41)	0.487	**1.59 (0.16, 3.03)**	**0.025**	0.02 (-0.67, 0.7)	0.699	0.37 (-0.63, 1.36)	0.513	0.11 (-0.18, 0.41)	0.487
Stringency index	**0.05 (0.03, 0.06)**	**<0.001**	**0.08 (0.01, 0.15)**	**0.031**	0.02 (-0.01, 0.05)	0.081	-0.03 (-0.07, 0.02)	0.302	**0.05 (0.03, 0.06)**	**<0.000**
Tests	**-0.35 (-0.49, -0.22)**	**<0.001**	-1.91 (-2.77, -1.04)	0.061	-0.50 (-0.91, -0.08)	0.166	**-0.87 (-1.47, -0.28)**	**0.008**	**-0.35 (-0.49, -0.22)**	**<0.001**
Vaccinations	-0.03 (-0.64, 0.59)	0.475	-0.01 (-0.53, 0.51)	0.211	0.16 (-0.27, 0.59)	0.531	-0.6 (-1.41, 0.21)	0.200	-0.03 (-0.64, 0.59)	0.475

CFR, case fatality rate; CI, confidence interval; CVD, cardiovascular diseases

Table S3. Changes in COVID-19 CFR (‰) per 10% increase in the ecological and socioeconomic variables (including GDP per capita instead of CO_2 emission per capita; and forest area per capita instead of forest cover)

Variables	All countries (N=186)		Low-income countries (N=26)		Lower-middle-income countries (N=50)		Upper-middle-income countries (N=51)		High-income countries (N=59)	
	CFR change (95% CI)	*p*-value	CFR change (95% CI)	*p*-value	CFR change (95% CI)	*p*-value	CFR change (95% CI)	*p*-value	CFR change (95% CI)	*p*-value
Forest area per capita	-0.04 (-0.23, 0.16)	0.666	**-2.12 (-2.75, -1.50)**	**0.005**	-0.15 (-0.44, 0.13)	0.416	0.19 (-0.16, 0.53)	0.336	0.03 (-0.04, 0.10)	0.493
GDP per capita	-0.41 (-0.95, 0.13)	0.161	1.02 (-1.87, 3.91)	0.364	**-0.73 (-1.44, -0.03)**	**0.014**	-0.46 (-1.68, 0.76)	0.522	-0.01 (-0.35, 0.32)	0.774
Population	0.06 (-0.08, 0.21)	0.411	0.54 (-0.29, 1.37)	0.211	0.25 (-0.01, 0.51)	0.144	0.23 (-0.04, 0.50)	0.132	0.02 (-0.03, 0.08)	0.522
Population density	-0.15 (-0.41, 0.11)	0.275	**-3.95 (-5.36, -2.54)**	**0.002**	-0.20 (-0.61, 0.21)	0.368	-0.02 (-0.54, 0.50)	0.692	0.05 (-0.04, 0.15)	0.371
Life expectancy	**0.12 (0.04, 0.2)**	**0.007**	**0.60 (0.39, 0.81)**	**0.002**	0.05 (-0.05, 0.15)	0.367	0.10 (-0.03, 0.23)	0.175	0.01 (-0.05, 0.07)	0.501
Male smoker	0.00 (-0.03, 0.02)	0.709	0.11 (-0.05, 0.26)	0.120	0.00 (-0.02, 0.03)	0.426	-0.01 (-0.06, 0.03)	0.496	-0.01 (-0.03, 0.01)	0.177
Female smoker	0.21 (-0.06, 0.48)	0.234	**1.26 (0.61, 1.92)**	**0.013**	0.23 (-0.21, 0.67)	0.425	0.00 (-0.40, 0.41)	0.545	**0.47 (0.30, 0.65)**	**<0.001**
CVD death rate	0.75 (-0.21, 1.72)	0.143	0.24 (-3.36, 3.83)	0.110	**-1.47 (-2.55, -0.39)**	**0.008**	-0.72 (-2.06, 0.61)	0.316	**0.98 (0.50, 1.45)**	**0.001**
Diabetes prevalence	0.31 (-0.33, 0.95)	0.352	-1.27 (-2.94, 0.40)	0.152	0.31 (-0.29, 0.90)	0.375	0.03 (-1.53, 1.58)	0.787	0.30 (-0.05, 0.66)	0.121
Hospital beds	-0.20 (-0.67, 0.27)	0.444	**2.33 (0.76, 3.90)**	**0.025**	-0.15 (-0.73, 0.44)	0.537	0.33 (-0.65, 1.32)	0.515	0.13 (-0.16, 0.41)	0.406
Stringency index	-0.01 (-0.04, 0.01)	0.313	-0.01 (-0.09, 0.07)	0.151	**0.02 (0.00, 0.05)**	**0.034**	-0.02 (-0.06, 0.03)	0.445	**0.05 (0.03, 0.06)**	**<0.001**
Tests	**-0.70 (-1.00, -0.41)**	**<0.001**	-1.12 (-2.07, -0.16)	0.089	-0.30 (-0.72, 0.12)	0.226	**-0.82 (-1.43, -0.21)**	**0.017**	**-0.35 (-0.48, -0.23)**	**<0.001**
Vaccinations	0.19 (-0.11, 0.49)	0.228	-0.07 (-0.62, 0.49)	0.203	0.05 (-0.35, 0.46)	0.699	-0.69 (-1.49, 0.12)	0.114	-0.03 (-0.65, 0.59)	0.654

CFR, case fatality rate; CI, confidence interval; CVD, cardiovascular diseases