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Economic growth and carbon emissions

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ABSTRACT

In this paper, we investigate the dynamic relationship between economic growth and carbon dioxide (CO_2) emissions for 181 countries. We propose a new approach based on the cross-correlation estimates to understand how economic growth and CO_2 emissions are related. Our proposal is that if there is a positive cross-correlation between the current level of income and the past level of CO_2 emissions and a negative cross-correlation between the current level of income and the future CO_2 emissions, then CO_2 emissions will decline with an increase in income over time, consistent with the environmental Kuznets curve (EKC) hypothesis. Our main findings can be summarized as follows. First, for 21 out of 181 countries (12%), there is clear evidence supporting the EKC hypothesis. Second, we ask whether a rise in income reduces emissions in the future. We find that for 49 countries (27%), income growth will reduce emissions in the future.

1. Introduction

The environmental Kuznets curve (EKC) hypothesis—that economic growth causes environmental degradation during the early stage of economic development following which economic growth reduces environmental degradation—has been a subject of intense applied research over the last two decades.[3] Typically, the literature is based on a regression framework in which environmental degradation is treated as endogenous while income is considered to be exogenous. Two features of this literature are appealing and have become prominent in the relatively recent studies on this subject. First, while the bulk of the early studies evaluated time series models of environmental degradation and economic growth, recent empirical frameworks have begun to entertain panel data regression models. The predilection for panel data models has been motivated by (a) short time series of data for many developing countries, which has prompted researchers to pool together countries in a panel setting, allowing them to circumvent the short sample limitation, and (b) recent theoretical research in econometrics, which has seen the advent of state-of-the-art methods in panel unit roots[4] and panel cointegration.[5]

The second feature of this literature is that a number of control variables, such as employment ratio (Ghosh, 2010), electricity consumption (Lean and Smyth, 2010), trade openness (Suri and Chapman, 1998), energy consumption (Saboori and Sulaiman, 2013), and political freedom (Torras and Boyce, 1998), among others, have been used to model the effect of economic growth on environmental degradation. This approach has been motivated by an absence of consensus from empirical findings on the EKC hypothesis. Despite using a range of control variables, the empirical evidence has remained mixed. The key point here is that a shift in approach from a conventional regression model of economic growth and environmental degradation variables to a multivariate regression model with a range of control variables has not improved empirical evidence supporting the EKC.

The lack of consensus on the EKC hypothesis has prompted a methodological response to understanding the EKC hypothesis. Narayan and Narayan (2010), for example, question the existing time series and panel data regression models on the ground that the regression model suffers from the issue of collinearity or multicollinearity, a result that seems rather obvious because these models contain both GDP and the

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[3] A large number of studies have considered carbon emissions, both on its relationship with economic growth and other variables; for some examples of these, see Farhani et al. (2014), Yang and Zhao (2014), Wang (2012) and Hoa and Limskul (2013).

[4] For applications that have influenced this literature, see Narayan and Smyth (2007), Narayan et al. (2008), Hsu et al. (2008), Lee et al. (2008), and the references cited therein.

[5] For influential applications, see Lee and Chang (2008) and Narayan and Smyth (2008), and the references cited therein.

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Table 1
Summary and descriptive statistics.

Country	Mean	SD	Correlation	*t*-statistics
Panel A: high-income OECD				
Australia	16141	4576	0.918	15.86***
Austria	16828	5824	0.842	10.699***
Belgium	16349	5217	−0.333	−2.418***
Canada	17634	4847	0.662	6.059***
Czech Republic	6026	1044	−0.584	−2.784**
Denmark	22021	6257	−0.007	−0.048
Estonia	4799	1402	0.564	2.369**
Finland	16667	6020	0.766	8.178***
France	16158	4758	−0.396	−2.955***
Germany	22503	1633	−0.925	−9.715***
Greece	9037	2873	0.95	20.868***
Hungary	3878	1058	−0.172	−1.13
Iceland	22858	7928	0.253	1.796*
Ireland	20601	10533	0.917	13.961***
Italy	13874	4567	0.919	15.967***
Japan	26347	10403	0.859	11.501***
Republic of Korea	6060	4482	0.985	38.803***
Luxembourg	28940	13245	−0.771	−8.293***
Netherlands	17201	5328	0.481	3.763***
New Zealand	12340	1635	0.771	6.631***
Norway	25182	9843	0.811	9.488***
Poland	4248	1038	−0.746	−4.625***
Portugal	7328	3049	0.985	38.95***
Slovak Republic	5723	1326	−0.714	−3.953***
Slovenia	10119	2052	0.739	4.253***
Spain	9970	3579	0.96	23.535***
Sweden	21206	5815	−0.638	−5.672***
Switzerland	32723	2761	−0.723	−5.433***
United Kingdom	17838	5867	−0.892	−13.548***
United States	25448	7502	0.114	0.7840
Panel B: high-income non-OECD				
Andorra	18646	2570	0.075	0.26
Bahamas	17599	2986	−0.504	−4.001***
Bahrain	11398	1895	0.165	0.871
Barbados	7257	1822	0.95	20.906***
Bermuda	41277	13031	0.628	5.53***
Brunei Darussalam	21248	3984	0.589	4.117***
Croatia	5015	1041	0.956	12.646***
Cyprus	10354	3348	0.977	25.826***
Equatorial Guinea	2687	2766	0.895	9.41***
French Polynesia	11636	2171	0.891	11.465***
Greenland	15948	3057	−0.001	−0.006
Hong Kong SAR, China	1579	9400	0.937	18.398***
Kuwait	21834	2392	0.646	2.928**
Macao SAR, China	15471	4879	0.307	1.612
Malta	6657	2839	0.842	9.509***
New Caledonia	10917	2059	−0.308	−1.885*
Oman	6253	2582	0.879	12.099***
Saudi Arabia	10705	2641	0.177	1.092
Singapore	13259	8874	0.505	4.006***
St. Kitts and Nevis	6859	2064	0.822	7.354***
Trinidad and Tobago	5785	1748	0.883	12.88***
United Arab Emirates	39698	10248	0.685	5.313***
Panel C: upper middle-income				
Algeria	1683	322	0.868	11.962***
Angola	763	230	0.745	4.604***
Antigua and Barbuda	8673	2672	0.249	1.409
Argentina	6858	1017	0.895	13.728***
Azerbaijan	919	503	0.353	1.46
Belarus	1451	473	0.05	0.194
Bosnia and Herzegovina	1470	536	0.979	17.199***
Botswana	2361	1064	0.918	13.097***
Brazil	3022	859	0.96	23.59***
Bulgaria	1681	354	−0.282	−1.527
Chile	3199	1373	0.923	16.448***
China	4900	508	0.967	25.995***
Colombia	2056	543	0.517	4.14***
Costa Rica	3119	884	0.971	27.636***
Cuba	2818	650	0.309	1.976*
Dominica	3951	1116	0.934	14.254***
Dominican Republic	1908	744	0.939	18.65***
Ecuador	1221	237	0.882	12.816***
Gabon	4285	1288	0.729	7.291***

Table 1 (*continued*)

Country	Mean	SD	Correlation	*t*-statistics
Panel C: upper middle-income				
Grenada	3717	1246	0.964	19.736***
Islamic Republic of Iran	1573	327	0.687	6.132***
Jamaica	3262	407	0.718	6.61***
Jordan	1831	291	0.701	5.557***
Kazakhstan	1501	471	0.602	2.917**
Latvia	3717	1364	−0.452	−1.962*
Lebanon	4569	737	0.649	3.722***
Lithuania	3762	1159	−0.159	−0.623
Macedonia, FYR	1773	185	−0.085	−0.33
Malaysia	2807	1186	0.988	38.764***
Maldives	2581	671	0.937	9.289***
Mauritius	2883	1043	0.991	41.756***
Mexico	4556	1092	0.941	19.008***
Namibia	2133	244	0.749	4.666***
Palau	6395	412	0.308	1.294
Panama	3232	804	0.725	7.206***
Peru	2083	265	0.803	9.238***
Romania	1956	316	0.091	0.474
Russian Federation	2039	478	0.276	1.114
Serbia	894	170	0.698	3.779***
Seychelles	4905	1948	0.882	12.388***
South Africa	3093	345	0.625	5.486***
St. Lucia	3847	1016	0.93	13.169***
St. Vincent and the Grenadines	2386	1133	0.976	30.733***
Suriname	2217	287	0.525	3.492***
Thailand	1183	730	0.99	48.108***
Tunisia	1602	621	0.962	23.851***
Turkey	3079	1032	0.986	40.853***
Turkmenistan	916	423	0.761	4.545***
Uruguay	5367	1147	0.032	0.219
Venezuela, RB	5478	625	−0.39	−2.904***
Panel D: lower middle-income				
Albania	1128	286	0.097	0.507
Armenia	771	364	0.926	9.467***
Belize	2150	937	0.659	6.009***
Bhutan	618	271	0.935	13.385***
Bolivia	989	90	0.391	2.91***
Cameroon	646	134	0.69	6.527***
Cape Verde	1012	361	0.93	13.174***
Republic of the Congo	967	231	0.425	3.219***
Côte d'Ivoire	728	148	0.556	4.588***
Djibouti	866	127	0.802	5.537***
Egypt, Arab Republic	989	412	0.979	32.706***
El Salvador	1908	330	0.786	8.713***
Fiji	1722	371	0.775	8.399***
Georgia	778	244	0.014	0.056
Ghana	256	34	0.266	1.895*
Guatemala	1464	248	0.896	13.823***
Guyana	800	143	0.564	4.682***
Honduras	1040	165	0.886	13.11***
India	314	137	0.964	24.763***
Indonesia	510	268	0.99	48.896***
Iraq	814	186	−0.665	−2.812**
Kiribati	944	421	0.752	6.935***
Lao PDR	302	86	0.94	12.876***
Marshall Islands	2271	150	0.533	2.6**
Moldova	448	88	0.33	1.356
Mongolia	507	88	0.1	0.513
Morocco	1057	290	0.98	33.592***
Nicaragua	989	267	0.098	0.672
Nigeria	359	59	0.595	5.08***
Pakistan	391	128	0.955	22.147***
Papua New Guinea	635	83	0.517	4.14***
Paraguay	1163	299	0.872	12.186***
Philippines	966	149	0.757	7.946***
Samoa	1356	239	0.918	11.597***
Senegal	522	45	−0.456	−3.511***
Solomon Islands	1148	167	0.433	1.98*
Sri Lanka	561	255	0.884	12.968***
Sudan	308	63	0.275	1.957*
Swaziland	1143	380	0.392	2.589**
Syrian Arab Republic	966	283	0.929	17.245***
Tonga	1730	257	0.969	19.942***
Ukraine	826	208	0.394	1.662
Uzbekistan	602	101	−0.363	−1.509

(*continued on next page*)