Economic growth and energy use during different stages of development: an empirical analysis

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Online Appendix

1. Stylized Facts

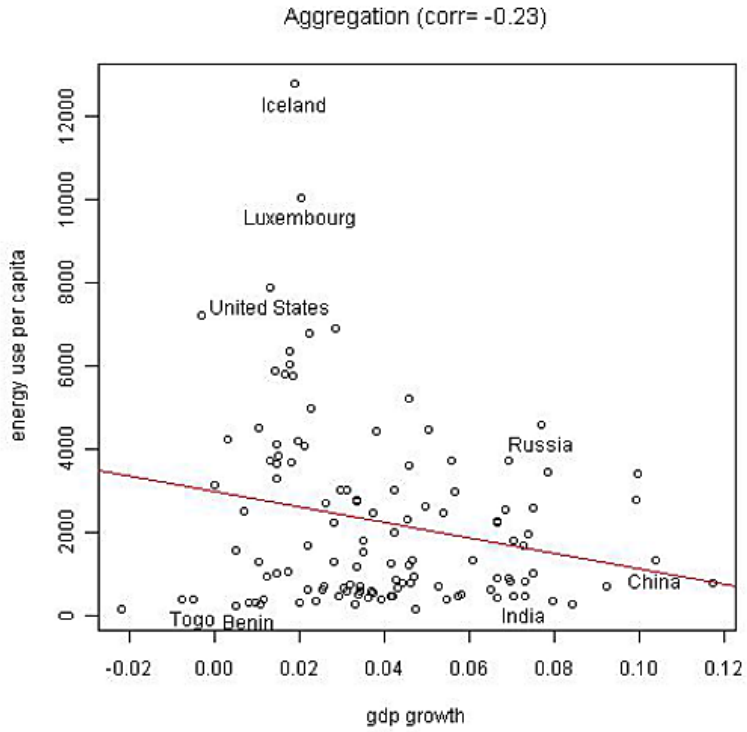

Figure A1. *Energy use and economic growth (both per capita)*
Data source: World Bank and Penn World Table (PWT 6.3)

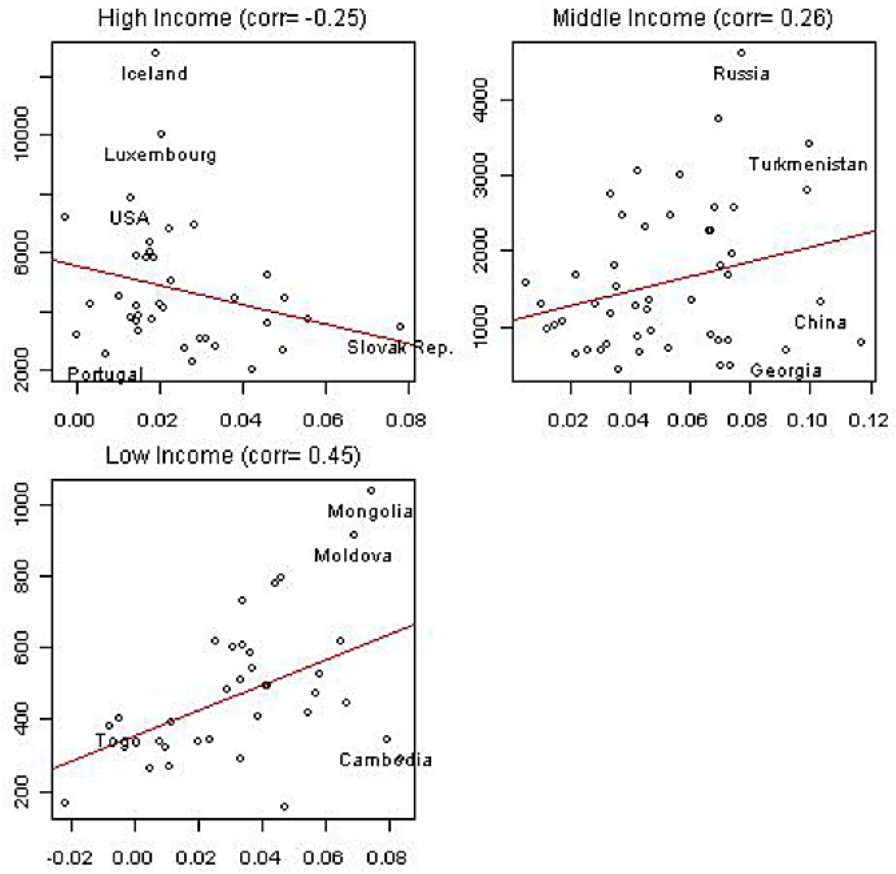

Figure A2. *Energy use and economic growth (both per capita) for country groups*
Data source: World Bank and Penn World Table (PWT 6.3)

2. Data

Table A1. *Countries included in the analysis by income groups*

High income group
Australia, Austria, Belgium, Brunei, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Korea Republic, Luxembourg, Malta, Netherlands, New Zealand, Norway, Oman, Portugal Saudia Arabia, Singapore, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, the UK, and USA.
Middle income group
Albania, Algeria, Argentina, Armenia, Belarus, Bosnia and Herzegovina, Botswana, Brazil Bulgaria, Chile, China, Colombia, Costa Rica, Dominican Republic, El Salvador, Gabon Georgia, Guatemala, India, Iran, Jamaica, Jordan, Kazakhstan, Latvia, Lebanon, Libya Lithuania, Macedonia, Malaysia, Mexico, Morocco, Namibia, Panama, Paraguay, Peru Poland, Romania, Russia, Serbia, South Africa, Syrian Arab Republic, Thailand, Tunisia Turkey, Turkmenistan, Ukraine, Uruguay, and Venezuela.
Low income group
Bangladesh, Benin, Bolivia, Cambodia, Cameroon, Democratic Republic of the Congo Egypt, Eritrea, Ethiopia, Ghana, Haiti, Honduras, Indonesia, Kenya, Kyrgyz Republic Moldova, Mongolia, Mozambique, Nepal, Nicaragua, Nigeria, Pakistan, the Philippines The Republic of Congo, Senegal, Sri Lanka, Sudan, Tajikistan, Tanzania, Togo Togo, Vietnam, Yemen, and Zambia.

3. Results

Collapsed instruments: growth regression

Parameter estimates do not change considerably when collapsing the number of instruments from 30 to 10 for GMM models and from 43 to 23 for SYS-GMM models (see table A2). Especially for SYS-GMM estimates, parameter signs and magnitude remain robust. Significance with regard to GMM estimates is weaker for population growth and openness. Energy neutrality and the positive effect for capital accumulation remain robust throughout all specifications. According to the Hansen tests in table A5, validity of the instruments is rejected in more cases when instruments are collapsed (for 8 out of 12 specifications).

Table A2. *Growth regressions: all samples with collapsed instruments only*

All countries N=732			**High income countries** N=233		
	GMM	SYS-GMM		GMM	SYS-GMM
	(1)	(2)		(5)	(6)
y(-1)	0.158***	-0.186***	y(-1)	-0.151**	-0.179***
	(0.127)	(0.048)		(0.079)	(0.048)
enuse	-0.158	0.015	enuse	0.104	0.086*
	(0.130)	(0.054)		(0.099)	(0.052)
ci	0.267***	0.198***	ci	0.185**	0.271***
	(0.059)	(0.037)		(0.090)	(0.048)
popg	-1.209	-1.834***	popg	2.679***	1.023
	(1.501)	(0.599)		(0.894)	(0.845)
openc	0.014	0.135***	openc	0.205**	0.068*
	(0.062)	(0.025)		(0.096)	(0.036)
Instruments	10	23		10	23
Middle income countries, N=280			**Low incomce countries**, N=209		
	GMM	SYS-GMM		GMM	SYS-GMM
	(1)	(2)		(5)	(6)
y(-1)	0.266***	-0.081***	y(-1)	-0.523*	0.103***
	(0.206)	(0.086)		(0.285)	(0.087)
enuse	-0.246	-0.038	enuse	0.091	-0.166
	(0.154	(0.098)		(0.236)	(0.135)
ci	0.360***	0.195***	ci	0.188**	0.086
	(0.083)	(0.058)		(0.088)	(0.080)
popg	-4.620***	-2.575***	popg	-3.301*	-2.703*
	(1.207)	(0.875)		(2.024)	(1.621)
openc	-0.038	0.129***	openc	0.046	0.045
	(0.102)	(0.049)		(0.061)	(0.091)
Instruments	10	23		10	23

Notes: Robust standard errors in parenthesis
*** p-value $\leq$ 0.01, ** p-value $\leq$ 0.05, * p-value $\leq$ 0.1

Collapsed instruments: capital regression

Collapsing the number of instruments (from 15 to 5 for GMM and from 27 to 17 for SYS-GMM) partly affects the significance level for energy use in the case of the GMM estimator, whereas the corresponding signs and magnitudes remain robust for SYS-GMM estimates (see table A3). Validity of instruments according to the Hansen tests remains stable after reducing the number of instruments.

Table A3. *Capital regressions: all samples with collapsed instruments only*

All countries N=732			**High income countries** N=233		
	GMM	SYS-GMM		GMM	SYS-GMM
	(1)	(2)		(5)	(6)
enuse	1.176	0.581***	enuse	-1.132**	-0.085
	(0.820)	(1.44)		(1.145)	(0.241)
pop	-0.535**	0.027	pop	0.924	0.031
	(0.237)	(0.047)		(1.420)	(0.032)
popg	0.084	2.087	popg	4.264	-7.782***
	(1.344)	(1.749)		(3.306)	(1.965)
cg	0.003	0.001	cg	0.004	-0.007**
	(0.002)	(0.002)		(0.009)	(0.003)
openc	0.246***	0.107	openc	0.047	0.098
	(0.061)	(0.066)		(0.173)	(0.088)
agedep	0.173	-0.016	agedep	-0.607	0.266
	(0.460)	(0.121)		(0.701)	(0.171)
shurb	-0.059	-0.363	shurb	1.197	0.545
	(0.282)	(0.235)		(1.786)	(0.448)
exp	-0.188	-0.112	exp	0.216	0.631
	(0.185)	(0.107)		(0.207)	(0.123)
Instruments	5	17		5	17
Middle income countries, N=280			**Low incomce countries**, N=209		
	GMM	SYS-GMM		GMM	SYS-GMM
	(1)	(2)		(5)	(6)
enuse	0.337	0.336**	enuse	2.288**	0.153
	(1.281)	(0.170)		(0.940)	(0.437)
pop	-0.931**	0.030	pop	-0.141	-0.034
	(0.370)	(0.040)		(0.542)	(0.073)
popg	1.656	5.037*	popg	0.319	0.879
	(1.850)	(2.818)		(2.228)	(5.844)
cg	-0.002	-0.005*	cg	0.005**	0.003
	(0.005)	(0.003)		(0.002)	(0.004)
openc	0.194**	0.106	openc	0.257**	-0.067
	(0.095)	(0.102)		(0.091)	(0.168)
agedep	-0.378	0.043	agedep	-0.087	-0.564
	(0.464)	(0.224)		(0.863)	(0.379)
shurb	-0.017	-0.390	shurb	0.417	-0.060
	(0.575)	(0.218)		(0.564)	(0.250)
exp	0.010	0.341	exp	-1.886	1.128
	(0.125)	(0.379)		(1.324)	(0.729)
Instruments	5	17		5	17

Notes: Robust standard errors in parenthesis

*** p-value $\leq$ 0.01, ** p-value $\leq$ 0.05, * p-value $\leq$ 0.1

Table A4. *Growth regressions: all samples including school enrollment*

All countries, with human capital, N=693						**High income countries**, with human capital N=220					
	OLS	RE	FE	GMM	SYS-GMM		OLS	RE	FE	GMM	SYS-GMM
	(11)	(12)	(13)	(14)	(15)		(16)	(17)	(18)	(19)	(20)
y(-1)	-0.013*	-0.016**	-0.068***	-0.032	-0.053	y(-1)	-0.030**	-0.025	-0.023	- 0.222*	-0.190***
	(0.008)	(0.009)	(0.024)	(0.081)	(0.044)		(0.013)	(0.018)	(0.035)	(0.114)	(0.041)
enuse	-0.005	-0.005	-0.008	0.028	-0.041	enuse	-0.005	-0.011	-0.004	0.126	0.099**
	(0.008)	(0.008)	(0.025)	(0.092)	(0.054)		(0.011)	(0.018)	(0.038)	(0.101)	(0.049)
ci	0.033***	0.037***	0.046**	0.227***	0.161***	ci	0.035***	0.060***	0.044	0.231***	0.273***
	(0.008)	(0.009)	(0.022)	(0.038)	(0.037)		(0.015)	(0.017)	(0.032)	(0.066)	(0.053)
popg	-1.033***	-1.053***	-0.850*	-1.215	-2.139***	popg	-0.065	-0.138	-0.172	1.531	1.918
	(0.219)	(0.207)	(0.444)	(1.232)	(0.611)		(0.394)	(0.507)	(1.096)	(1.474)	(1.140)
openc	0.020***	0.024***	0.081***	0.058	0.091***	openc	0.026***	0.029***	0.097***	0.221**	0.071***
	(0.005)	(0.006)	(0.016)	(0.051)	(0.030)		(0.005)	(0.008)	(0.033)	(0.092)	(0.022)
enroll	0.002	0.002	0.001	-0.001	0.014**	enroll	0.001	0.002	0.005*	-0.001	-0.008
	(0.003)	(0.002)	(0.003)	(0.007)	(0.007)		(0.003)	(0.002)	(0.003)	(0.004)	(0.008)
R-squared	0.133	0.127	0.101				0.271	0.256	0.185		
Wald	<2.2e-16	<2.2e-16	<2.2e-14	<2.2e-16	<2.2e-16		<2.2e-14	<2.2e-12	<2.2e-8	<2.2e-16	<2.2e-16
Sargan				0.001	0.007					0.264	0.057
Instruments				30	43					30	43
Middle income countries, with human capital, N=240						**Low income countries**, with human capital N=203					
	OLS	RE	FE	GMM	SYS-GMM		OLS	RE	FE	GMM	SYS-GMM
	(11)	(12)	(13)	(14)	(15)		(16)	(17)	(18)	(19)	(20)
y(-1)	-0.057***	-0.058***	-0.139***	-0.148*	-0.034	y(-1)	-0.004	-0.010	-0.081**	- 0.559***	0.104
	(0.017)	(0.014)	(0.043)	(0.088)	(0.016)		(0.013)	(0.012)	(0.035)	(0.180)	(0.085)
enuse	0.004	0.003	0.012	0.043	-0.006	enuse	-0.019	-0.021	0.028	0.078	-0.121
	(0.015)	(0.012)	(0.038)	(0.118)	(0.064)		(0.016)	(0.015)	(0.035)	(0.184)	(0.128)
ci	0.037***	0.042***	0.121***	0.263***	0.093	ci	0.021*	0.023*	0.028	0.179***	0.038
	(0.013)	(0.015)	(0.021)	(0.054)	(0.073)		(0.012)	(0.013)	(0.034)	(0.053)	(0.041)
popg	-1.245***	-1.298***	-1.865***	-3.456***	-3.070***	popg	-1.159**	-1.085**	-0.794	-3.324***	-4.139***
	(0.364)	(0.278)	(0.542)	(1.225)	(0.554)		(0.473)	(0.514)	(0.671)	(1.269)	(0.905)
openc	0.022**	0.025***	0.107***	0.086	0.043	openc	0.014	0.022*	0.069***	0.067	-0.004
	(0.009)	(0.009)	(0.030)	(0.077)	(0.039)		(0.015)	(0.011)	(0.023)	(0.055)	(0.051)
enroll	0.005	0.004	-0.006	0.001	0.018	enroll	-0.001	0.001	0.003	0.010	0.026
	(0.005)	(0.005)	(0.006)	(0.009)	(0.013)		(0.006)	(0.005)	(0.006)	(0.014)	(0.026)
R-squared	0.169	0.176	0.160				0.040	0.064	0.103		
Wald	<2.2e-10	<2.2e-9	<2.2e-8	<2.2e-16	<2.2e-16		0.027	0.034	0.001	<2.2e-7	<2.2e-16
Sargan				0.234	0.328					0.107	0.127
Instruments				30	43					30	43

Notes: Robust standard errors in parenthesis
*** p-value ≤ 0.01, ** p-value ≤ 0.05, * p-value ≤ 0.1

Table A5. *Specification tests*

Growth Regressions

	Hausmann	Hansen test GMM		Hansen test SYS-GMM		Difference-in-Hansen test	
	(1)	(2) all instr.	(3) collapsed inst.	(4) all instr.	(5) collapsed instr.	(6) all instr.	(7) collapsed instr.
All countries	5.545e-07	0.008	0.003	0.005	0.001	0.125	0.023
High income countries	0.001	0.205	0.014	0.039	0.017	0.801	0.650
Middle income countries	3.053e-05	0.311	0.044	0.625	0.001	0.930	0.003
Low income countries	0.005	0.764	0.156	0.182	0.071	0.735	0.056

Capital Regressions

	Hausmann	Hansen test GMM		Hansen test SYS-GMM		Difference-in-Hansen test	
	(1)	(2) all instr.	(3) collapsed inst.	(4) all instr.	(5) collapsed instr.	(6) all instr.	(7) collapsed instr.
All countries	6.736e-14	0.001	0.001	0.001	0.003	0.132	0.147
High income countries	7.568e-08	0.121	0.601	0.286	0.222	0.680	0.142
Middle income countries	0.569	0.217	0.019	0.095	0.043	0.114	0.231
Low income countries	5.935e-15	0.128	0.278	0.258	0.077	0.601	0.076

Notes: All numbers reported are p-values