The Energy Paradox: Energy Use And Happiness*

Draft: Wednesday 5th September, 2018

aSUPPLEMENTARY ONLINE MATERIAL

Contents

1 Country-level

Table S1: Key variables for each country."

"Country Code (ISO 2 digits)"	"Country Name"	"happiness (WDH)"	"energy use, pc"	"PCGDP"	"co2 emissions, pc"	"female life expectancy"
AD	Andorra	6.8		45,030	7.1	
AE	United Arab Emirates	7.3	9,742	54,113	26.3	77
AF	Afghanistan	4.1		413	0.1	59
AL	Albania	4.6	675	3,127	1.3	78
AM	Armenia	5.0	790	2,462	1.4	75
AO	Angola	4.3	462	2,484	0.9	55
AR	Argentina	7.3	1,720	8,501	4.0	78
AT	Austria	7.4	3,910	44,652	8.4	82
AU	Australia	7.7	5,680	48,171	17.4	83
AZ	Azerbaijan	5.3	1,467	3,251	3.8	72
BA	Bosnia and Herzegovina	5.8	1,325	3,820	4.3	78
BD	Bangladesh	5.3	162	601	0.3	68
BE	Belgium	7.3	5,489	42,509	10.4	82
BF	Burkina Faso	4.4		501	0.1	54
BG	Bulgaria	4.4	2,500	5,428	6.1	76
BI	Burundi	2.9		226	0.0	54
BJ	Benin	3.0	335	731	0.4	59
BO	Bolivia	6.3	566	1,732	1.3	65
BR	Brazil	7.5	1,154	9,540	1.9	76
BW	Botswana	4.7	1,027	5,576	2.2	54
BY	Belarus	5.2	2,727	4,099	5.9	75
BZ	Belize	6.6	579	4,216	1.6	72
CA	Canada	7.8	8,190	46,272	16.9	83
CD	Congo, Dem. Rep.	4.4	303	299	0.0	55
CF	Central African Republic	4.6		421	0.1	46
CG	Congo, Rep.	3.7	291	2,458	0.3	56
CH	Switzerland	8.0	3,528	70,752	5.5	84
CI	Cote d'Ivoire	4.4	464	1,242	0.4	49
CL	Chile	6.7	1,724	11,011	3.9	80
CM	Cameroon	3.9	387	1,249	0.3	53
CN	China	6.3	1,319	2,772	4.3	75
CO	Colombia	7.7	634	5,340	1.4	76
CR	Costa Rica	8.5	888	7,055	1.6	80
CY	Cyprus	7.1	2,252	30,090	7.4	81
CZ	Czech Republic	6.5	4,281	17,605	11.7	79
DE	Germany	7.1	4,072	39,569	9.8	82
DJ	Djibouti	5.7	177		0.5	60
DK	Denmark	8.3	3,560	58,061	9.4	80
DO	Dominican Republic	7.5	774	4,481	2.2	75
DZ	Algeria	5.4	982	4,065	3.0	74
EC	Ecuador	6.4	705	4,162	2.1	77
EE	Estonia	6.0	3,764	13,789	12.0	78
EG	Egypt, Arab Rep.	5.7	752	2,164	2.1	72

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*We thank anonymous reviewer for pointing that the relation between energy use and happiness is very similar to the relation between economic growth and happiness (i.e., the Happiness Paradox).

Table S1 – continued from previous page

"Country Code (ISO 2 digits)"	"Country Name"	"happiness (WDH)"	"energy use, pc"	"PCGDP"	"co2 emissions, pc"	"female life expectancy"	""
ES	Spain	7.2	3,098	30,648	7.5	84	
ET	Ethiopia	4.2	482	238	0.1	57	
FI	Finland	7.9	6,720	44,688	11.5	82	
FR	France	6.6	4,180	39,984	5.9	84	
GB	United Kingdom	7.2	3,592	38,623	8.8	81	
GE	Georgia	4.3	686	2,117	1.2	76	
GH	Ghana	5.2	293	1,087	0.4	59	
GN	Guinea	4.5		618	0.2	54	
GR	Greece	6.4	2,669	27,164	8.7	82	
GT	Guatemala	7.2	605	2,675	0.9	73	
GY	Guyana	6.5	658	2,565	2.1	68	
HK	Hong Kong SAR, China	6.6	1,993	26,963	6.1	85	
HN	Honduras	7.0	533	1,781	1.0	74	
HR	Croatia	6.0	2,121	12,748	4.9	79	
HT	Haiti	3.9	312	716	0.2	61	
HU	Hungary	5.5	2,586	12,466	5.5	77	
ID	Indonesia	6.3	779	2,508	1.5	69	
IE	Ireland	7.6	3,486	48,906	10.4	81	
IL	Israel	7.0	2,895	27,962	9.0	82	
IN	India	5.5	458	964	1.1	65	
IQ	Iraq	4.7	1,021	3,958	3.5	71	
IR	Iran, Islamic Rep.	5.9	2,341	5,594	6.6	73	
IS	Iceland	8.2	12,501	41,289	7.3	83	
IT	Italy	6.7	3,091	36,992	7.9	84	
JM	Jamaica	6.7	1,364	4,867	3.7	76	
JO	Jordan	5.9	1,059	3,330	3.3	74	
JP	Japan	6.5	3,978	43,598	9.5	86	
KE	Kenya	3.7	445	870	0.3	58	
KG	Kyrgyz Republic	5.5	508	759	1.1	72	
KH	Cambodia	4.9	283	594	0.2	65	
KR	Korea, Rep.	6.0	4,339	18,258	9.9	81	
KW	Kuwait	6.6	10,366	42,898	29.2	75	
KZ	Kazakhstan	6.1	3,371	6,890	11.4	72	
LA	Lao PDR	6.2		844	0.2	63	
LB	Lebanon	4.7	1,374	7,005	4.3	78	
LK	Sri Lanka	5.1	450	2,139	0.6	77	
LR	Liberia	4.3		324	0.2	56	
LT	Lithuania	5.5	2,649	10,087	4.1	78	
LU	Luxembourg	7.7	8,574	101,171	22.2	82	
LV	Latvia	5.4	1,947	10,269	3.3	77	
MA	Morocco	5.4	454	2,362	1.4	73	
MD	Moldova	4.9	906	1,305	1.2	72	
ME	Montenegro	5.2	1,860	5,714	3.7	76	
MG	Madagascar	3.7		420	0.1	62	
MK	Macedonia, FYR	4.7	1,357	3,788	5.2	76	
ML	Mali	4.7		649	0.1	52	
MN	Mongolia	5.7	1,177	2,055	3.8	69	
MR	Mauritania	4.9		1,097	0.5	62	
MT	Malta	7.1	2,005	19,496	6.2	82	
MW	Malawi	6.2		385	0.1	52	
MX	Mexico	7.9	1,567	9,014	4.2	78	
MY	Malaysia	6.5	2,432	7,850	6.4	76	
MZ	Mozambique	3.8	406	334	0.1	53	
NA	Namibia	5.2	627	4,382	1.1	57	
NE	Niger	3.8	129	332	0.1	54	
NG	Nigeria	5.7	737	1,746	0.7	49	
NI	Nicaragua	7.1	516	1,413	0.8	75	
NL	Netherlands	7.6	4,895	48,431	11.0	82	
NO	Norway	7.9	5,972	86,844	9.7	82	
NP	Nepal	5.3	353	503	0.1	66	
NZ	New Zealand	7.5	4,197	32,122	8.3	82	
PA	Panama	7.8	874	6,336	2.1	79	
PE	Peru	6.2	481	3,885	1.3	75	
PH	Philippines	5.9	458	1,803	0.9	71	
PK	Pakistan	5.0	487	947	0.9	65	
PL	Poland	6.4	2,424	10,050	8.0	79	
PS	West Bank and Gaza	4.9		2,259	0.5	73	
PT	Portugal	5.7	2,408	22,062	5.8	81	
PY	Paraguay	6.8	712	2,756	0.7	73	
QA	Qatar	6.8	19,050	63,770	57.1	78	
RO	Romania	5.7	1,791	6,794	4.5	76	
RS	Serbia	5.4	2,166	4,486	6.9	76	
RU	Russian Federation	5.5	4,505	8,714	11.2	73	
RW	Rwanda	4.3		426	0.1	56	
SA	Saudi Arabia	6.5	5,315	18,565	15.8	75	
SD	Sudan	5.0	381	1,215	0.3	62	
SE	Sweden	7.8	5,532	48,956	5.6	83	
SG	Singapore	6.9	5,278	38,239	8.7	82	
SI	Slovenia	6.9	3,532	21,762	7.8	81	
SK	Slovak Republic	5.9	3,392	13,220	7.1	78	
SL	Sierra Leone	3.5		346	0.1	44	
SN	Senegal	4.5	254	941	0.4	62	
SV	El Salvador	6.7	725	2,829	1.1	75	
SY	Syrian Arab Republic	5.9	1,037		3.0	76	
TD	Chad	5.4		687	0.0	49	
TG	Togo	2.6	424	486	0.3	55	
TH	Thailand	6.6	1,434	4,204	3.6	76	
TJ	Tajikistan	5.1	336	574	0.4	71	
TM	Turkmenistan	7.2	3,902	3,002	9.8	69	
TN	Tunisia	5.9	832	3,483	2.2	77	
TR	Turkey	5.6	1,262	9,237	3.6	76	

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Table S1 – continued from previous page

"Country Code (ISO 2 digits)"	"Country Name"	"happiness (WDH)"	"energy use, pc"	"PCGDP"	"co2 emissions, pc"	"female life expectancy" ""
TT	Trinidad and Tobago	7.0	11,620	13,646	27.7	73
TZ	Tanzania	2.8	426	591	0.1	57
UA	Ukraine	5.0	2,871	2,604	6.8	74
UG	Uganda	4.8		487	0.1	54
US	United States	7.4	7,725	47,470	19.2	80
UY	Uruguay	6.7	939	9,240	1.8	79
UZ	Uzbekistan	6.0	1,901	1,007	4.7	71
VE	Venezuela, RB	7.5	2,176	12,371	6.5	77
VN	Vietnam	6.1	472	991	1.1	79
YE	Yemen, Rep.	4.8	307	1,194	0.9	63
ZA	South Africa	5.8	2,595	6,544	8.8	57
ZM	Zambia	5.0	598	1,111	0.2	51
ZW	Zimbabwe	3.0	741	904	0.8	47

Figure S3 shows Gross Domestic Product (GDP) per capita against energy use per capita. It confirms earlier argument that there is some minimum threshold for energy consumption below which, more increase is desirable. That is developing countries should increase their energy consumption. Here, it is clear that at low levels, say below 2,000, no country reaches 20k in gdp, and at higher levels of energy use, there is wide variability in gdp. On the other hand, at low levels of GDP, there is quite a bit of variability in energy use. While moderate or even high happiness is possible at low level of energy consumption (figure **??**), moderate wealth is not possible, and moderate wealth in turn is important for happiness.

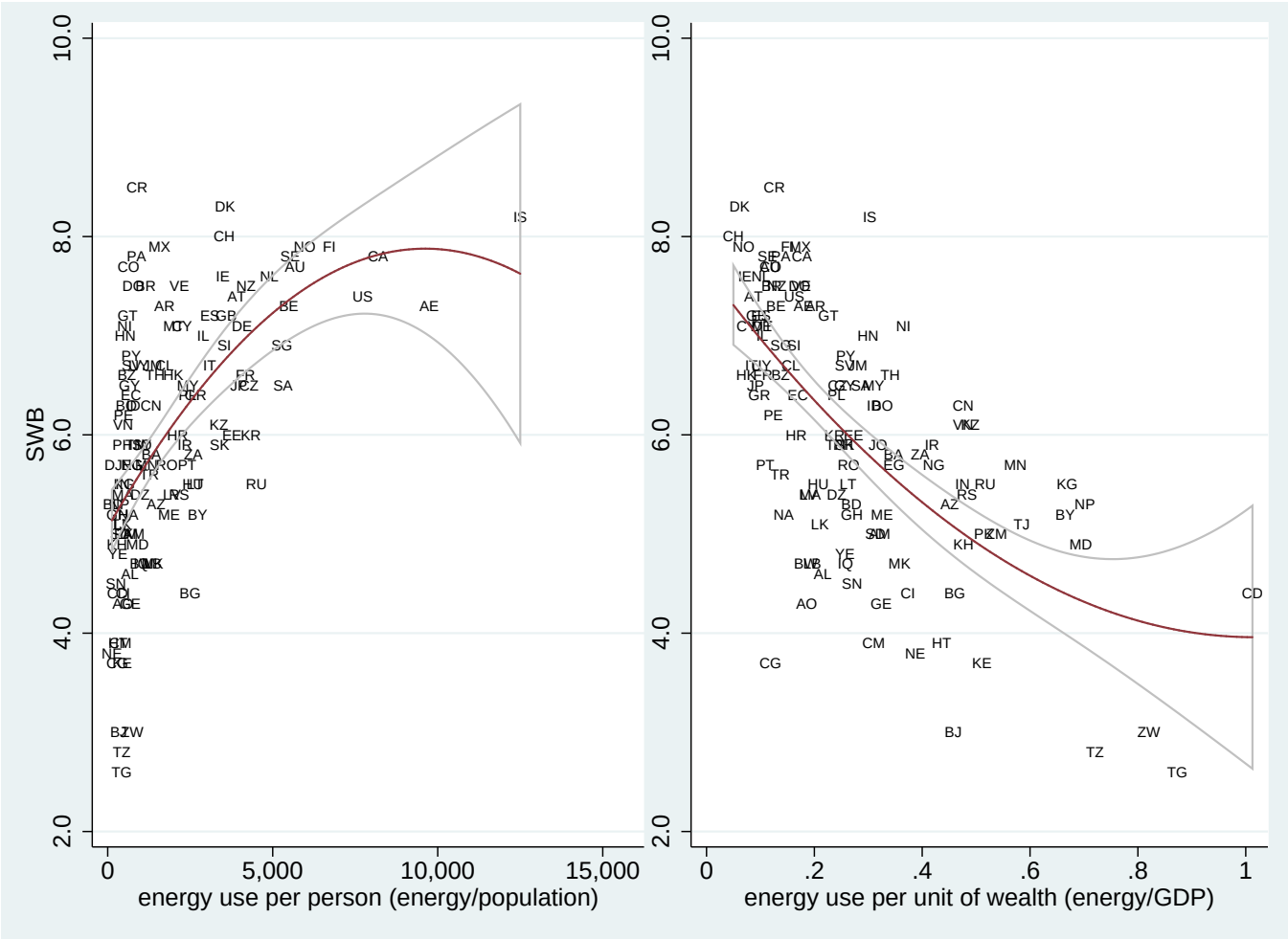

Figure S1: Repeated figure 1 from the body of the paper.

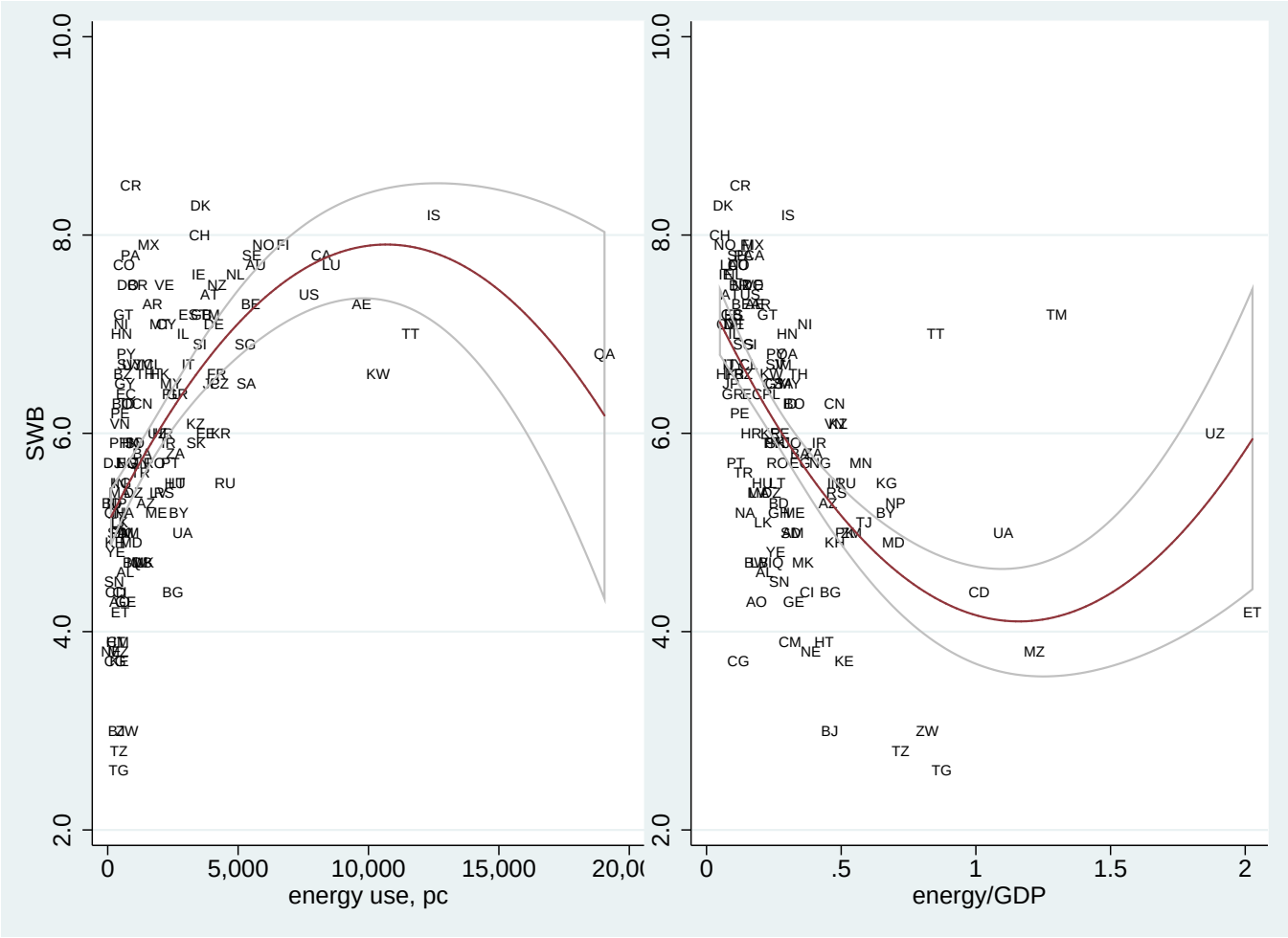

Figure S2: Repeated figure 1 from the body of the paper without dropping outliers.

Figures below explore interrelationships between energy, income, and SWB.

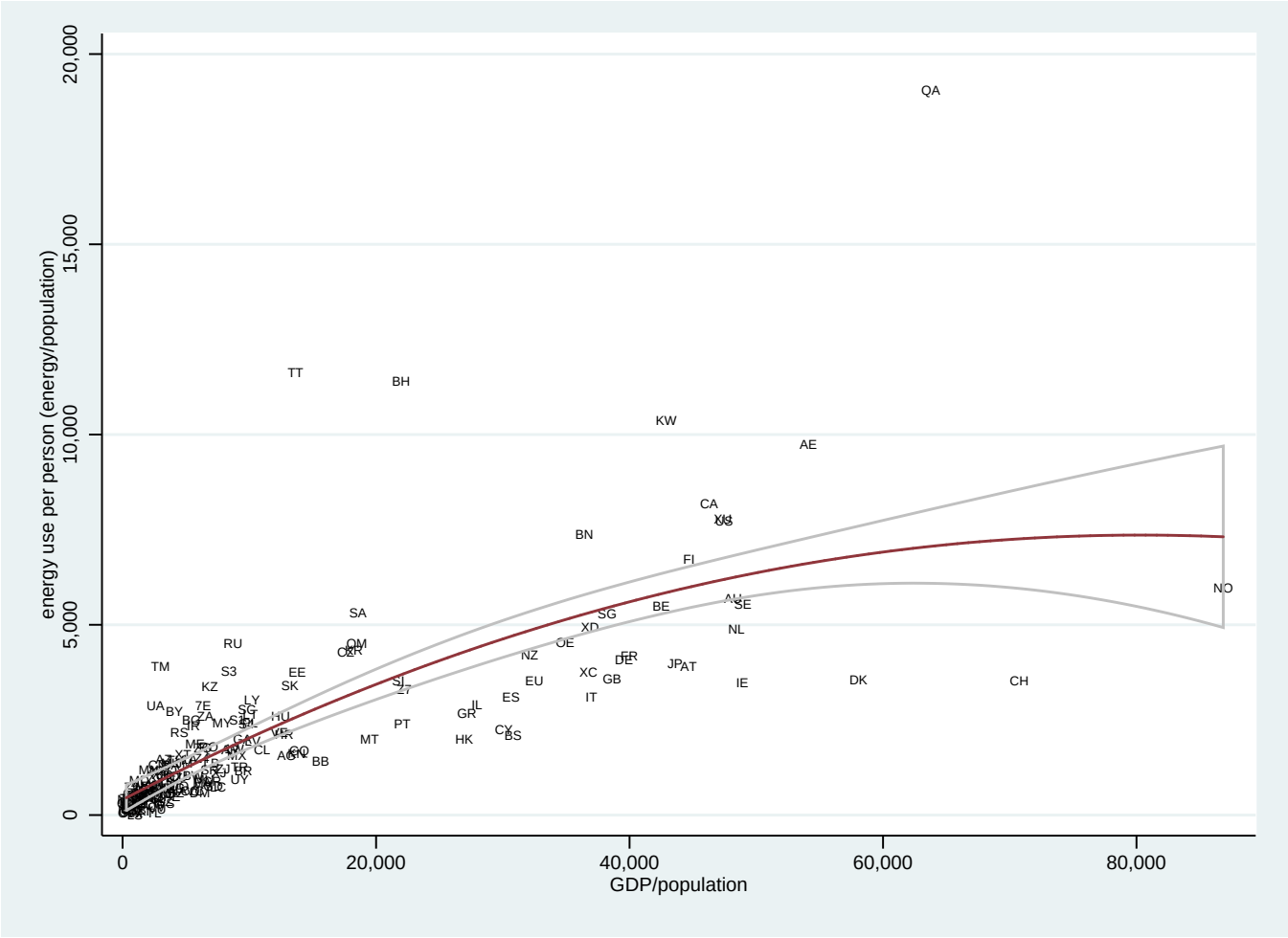

Figure S3: Energy use per capita against GDP per capita. Several outliers were dropped: "IS","UZ","ET","LU".

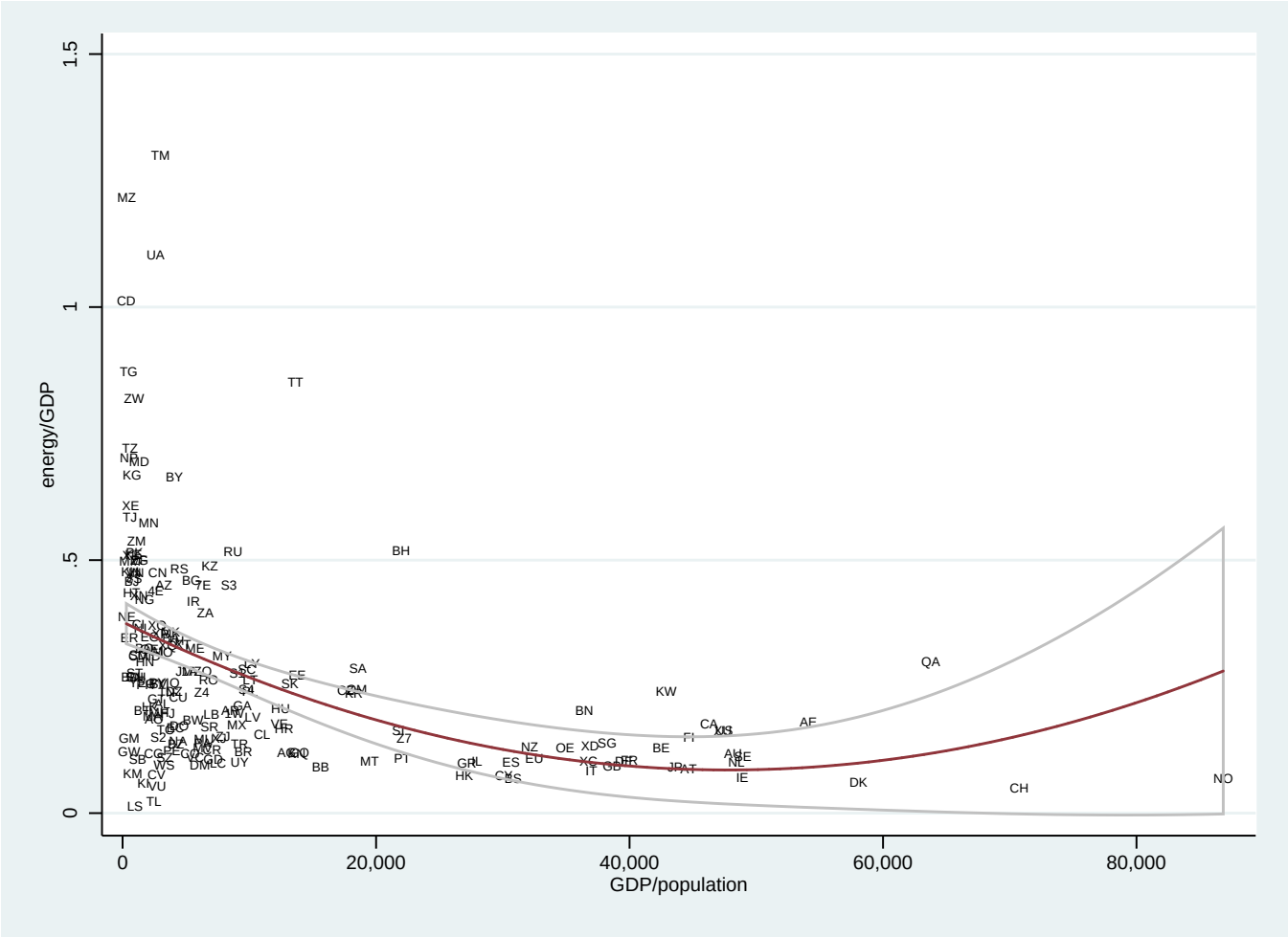

Figure S4: Energy per GDP and GDP per capita. Several outliers were dropped: "IS","UZ","ET","LU".

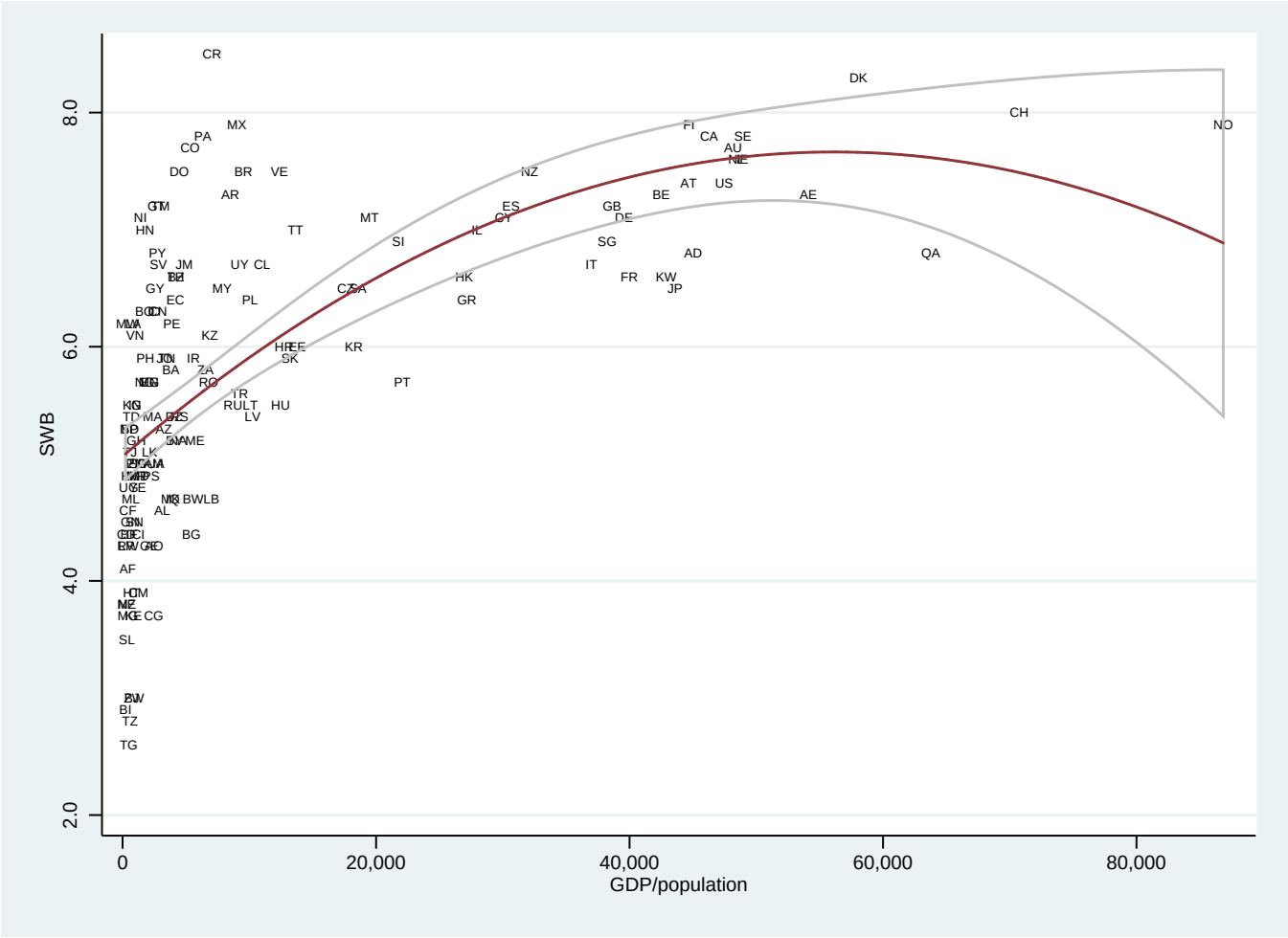

Figure S5: SWB and GDP per capita. Several outliers were dropped: "IS","UZ","ET","LU".

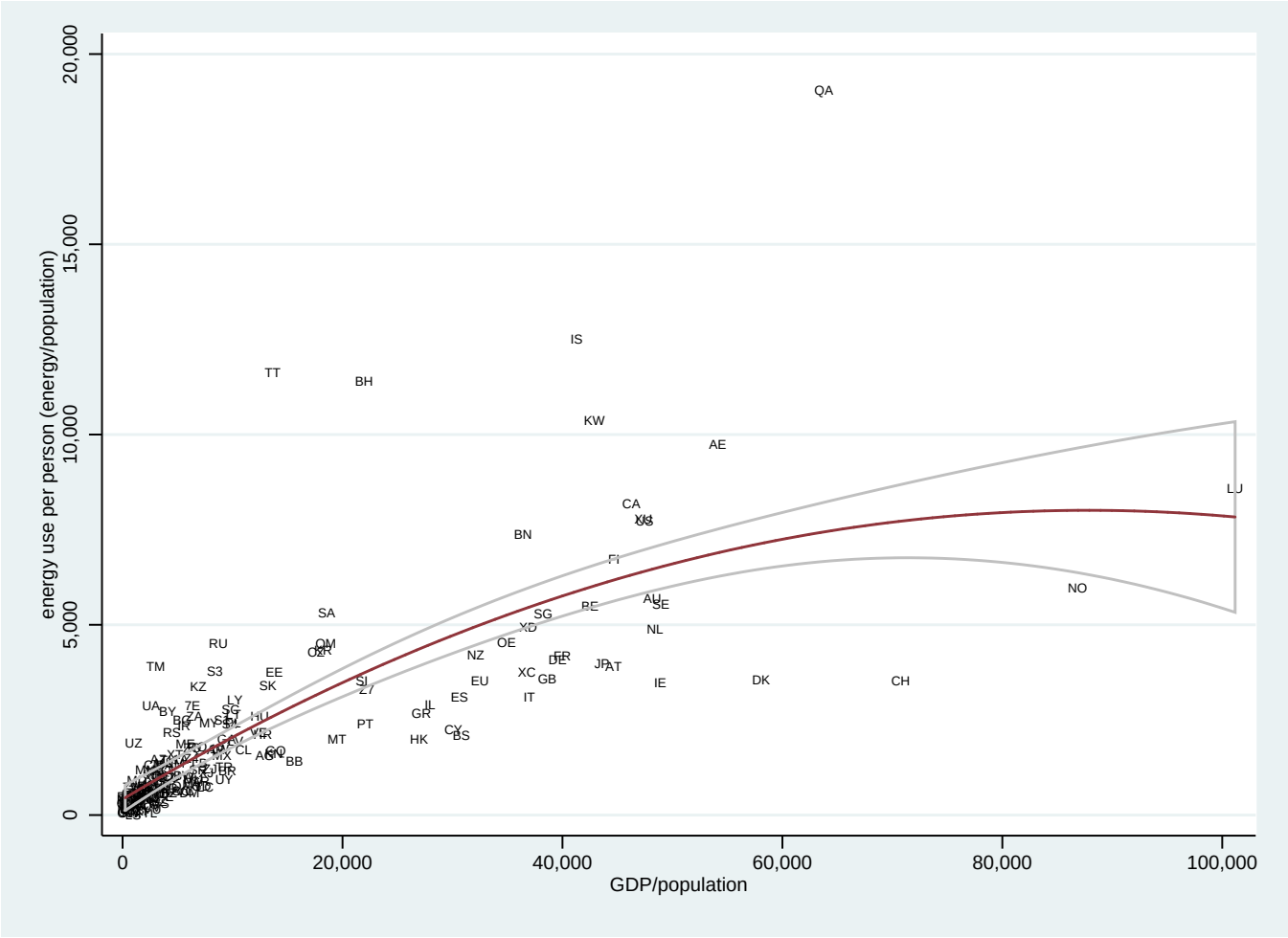

Figure S6: Energy per capita and GDP per capita, no outliers dropped.

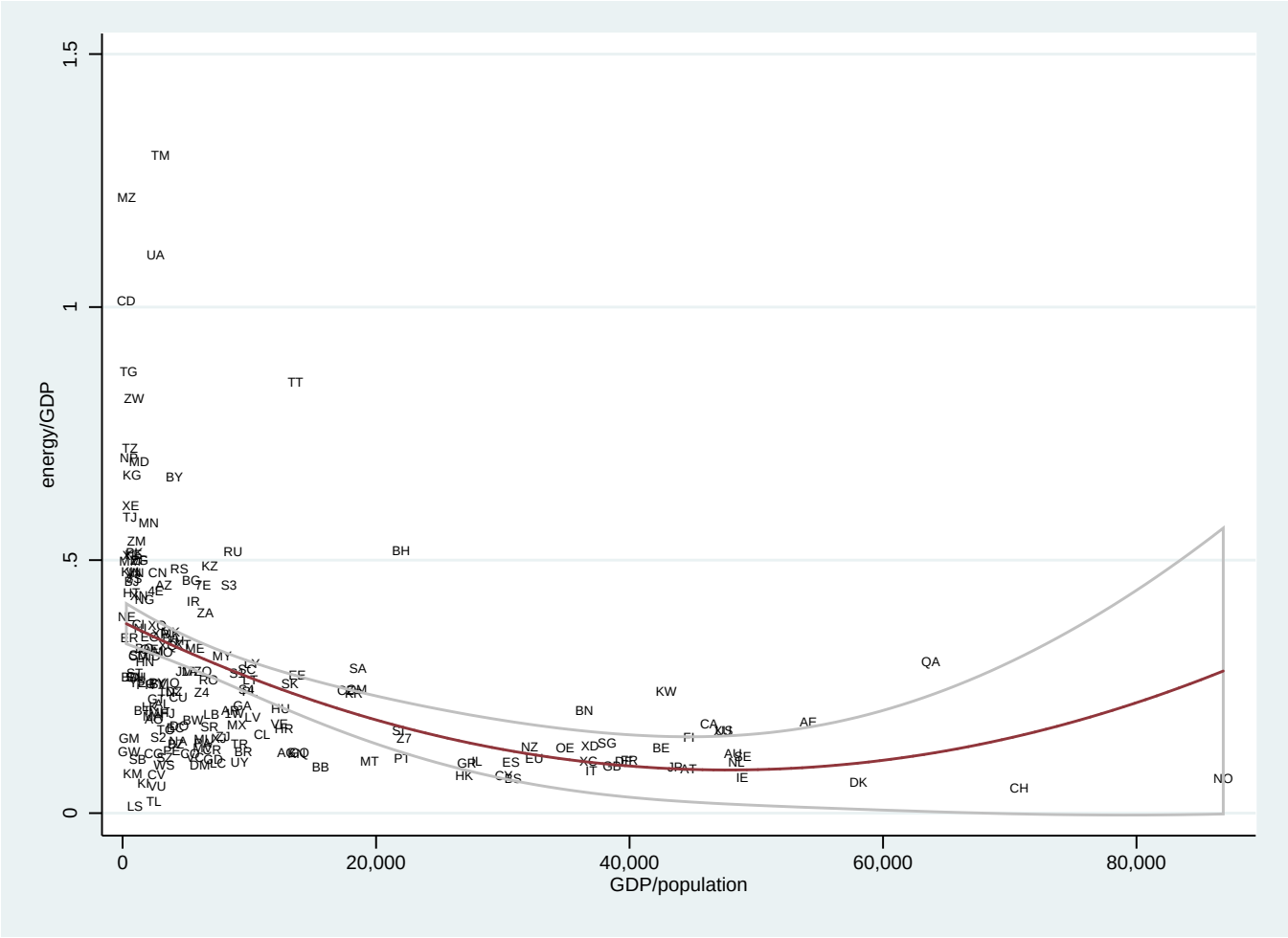

Figure S7: Energy per GDP and GDP per capita, no outliers dropped.

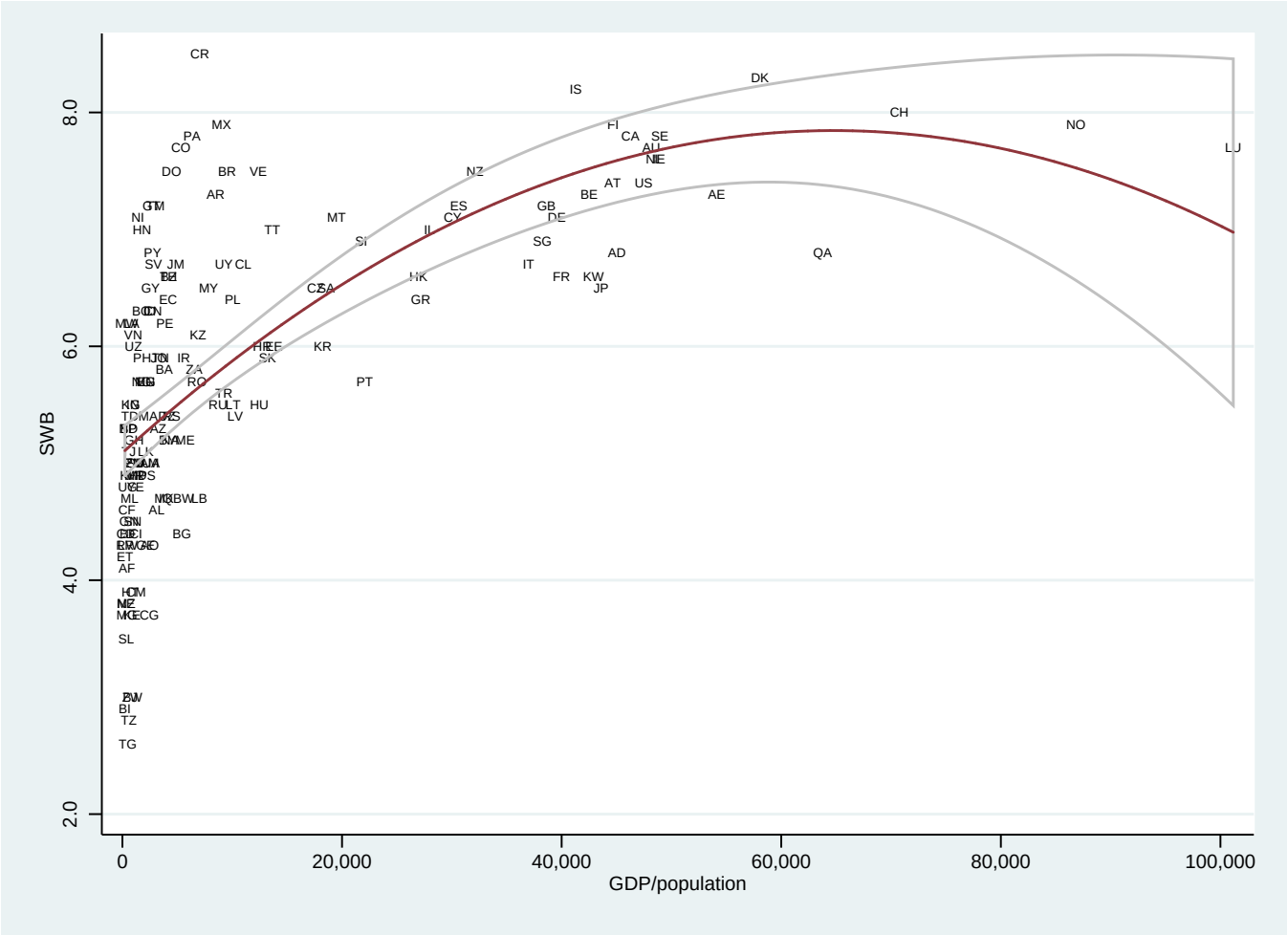

Figure S8: SWB and GDP per capita, no outliers dropped.

2 Census division-level

Figure S9 shows relationship between GDP and residential energy use across US census divisions. There is not much relationship: some census divisions display positive correlations and some negative. Weak relationship is not due to use of residential energy (total energy use is similarly related to GDP). It is rather, that in developed countries, energy has lower relationship with GDP. While there is clear positive relationship across countries as shown in previous section, there is not much relationship over time in the US.

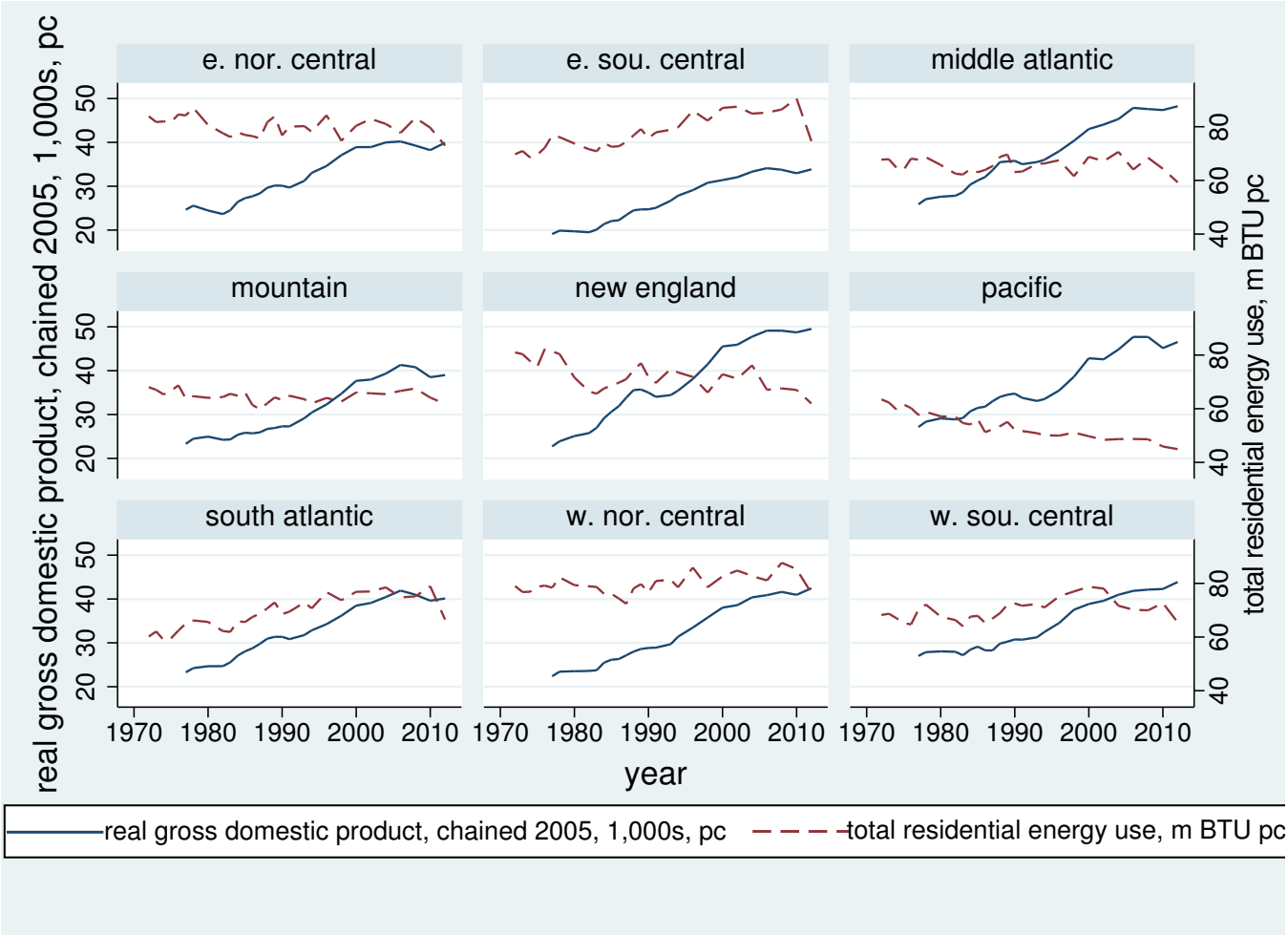

Figure S9: Real Gross Domestic Product (GDP) per capita and residential energy use per capita across census regions.

Figure S10 shows relationship between GDP and happiness across US census divisions. Here, unexpectedly, the relationship is moderately negative, or even strongly negative in Pacific and Mountain. It is only weakly positive in Middle Atlantic.

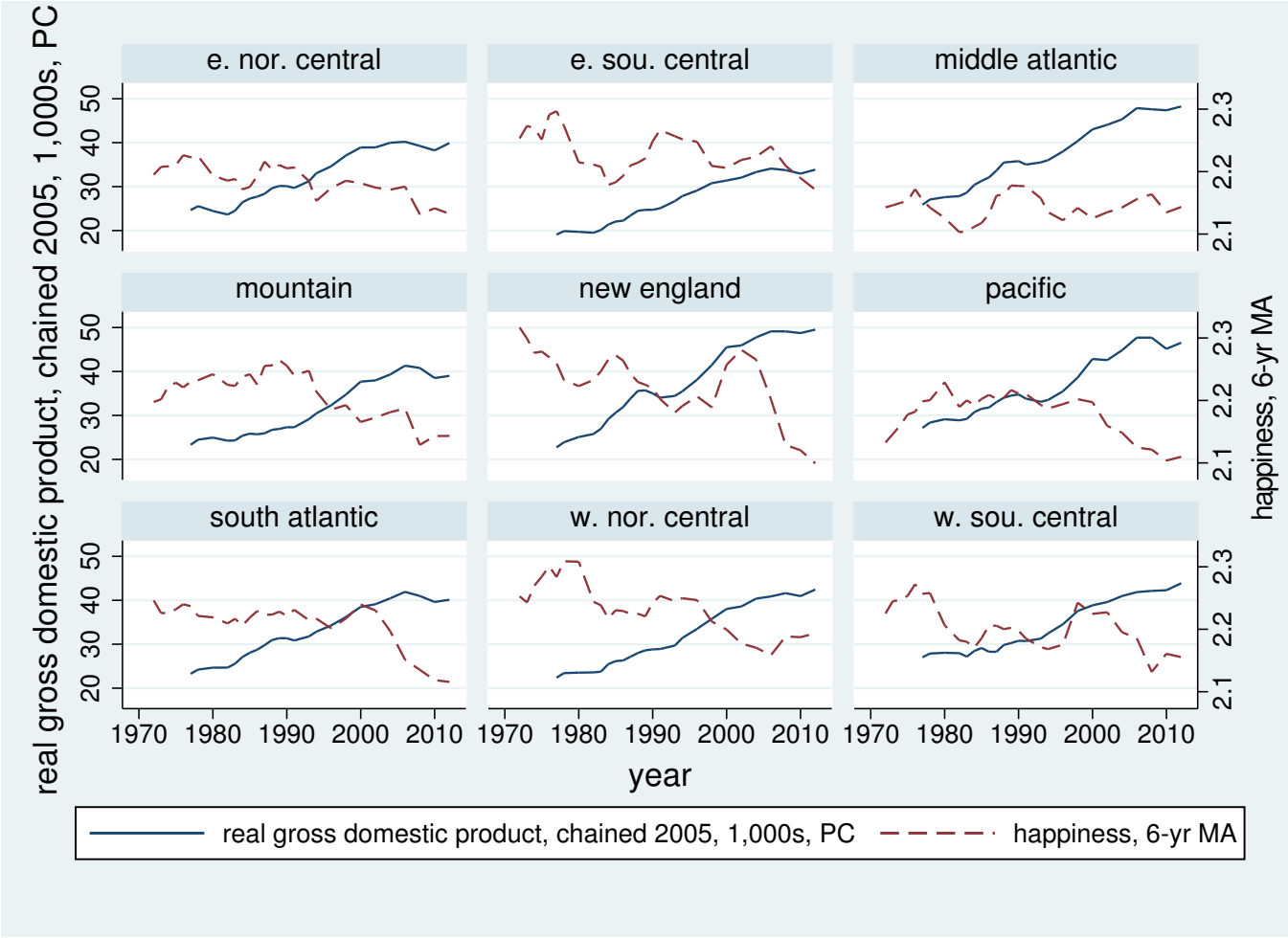

Figure S10: Happiness and Real Gross Domestic Product (GDP) per capita across census regions.

3 US energy use descriptive statistics

How do we use energy in the US? Energy use in the US has been fairly flat over past 40 years at 70m btu pc.(`http://www.eia.gov/todayinenergy/detail.cfm?id=3590`), and coasts consume less than inland middle (`http://energy.gov/maps/2009-energy-consumption page=0%2C1`). Use by sector in the US is following: 22% residential, 18% commercial, 32% industrial, and 28% transportation.(`http://www.eia.gov/consumption/`). Total energy consumption by end use is shown in table S2.

Table S2: Total energy consumption by end use; quadrillion Btu, 2011.

Space Heating	5.6
Space Cooling	2.6
Water Heating	2.7
Refrigeration	1.2
Cooking	0.6
Clothes Dryers	0.7
Freezers	0.2
Lighting	2
Clothes Washers	0.1
Dishwashers 1/ 0.307437 Televisions and Related Equipment	1
Computers and Related Equipment	0.4
Furnace Fans and Boiler Circulation Pumps	0.4
Other Uses	3.7

How is electricity used in US homes? Data are shown in table S3. It is important to note that end uses of energy changed over time, for instance from 1993 to 2009: appliances share increased from 24% to 35% and space heating dropped from 53% to 41% (`http://www.eia.gov/todayinenergy/detail.cfm?id=10271&src=%E2%80%B9%20Consumption%20%20%20%20%20%20Residential%20Energy%20Consumption%20Survey%20%28RECS%29-b1`).

Table S3: Estimated US residential electricity consumption by end use, 2012 (`www.eia.gov/tools/faqs/faq.cfm?id=96&t=3`).

End Use	Quadrillion Btu	Billion kilowatthours	% Share of total
Space cooling	0.85	250	18.00%
Lighting	0.64	186	14.00%
Water heating	0.45	130	9.00%
Refrigeration	0.38	111	8.00%
Televisions and related equipment	0.33	98	7.00%
Space heating	0.29	84	6.00%
Clothes dryers	0.2	59	4.00%
Computers and related equipment	0.12	37	3.00%
Cooking	0.11	31	2.00%
Dishwashers	0.1	29	2.00%
Furnace fans and boiler circulation pumps	0.09	28	2.00%
Freezers	0.08	24	2.00%
Clothes washers3	0.03	9	1.00%
Other uses	1.02	299	22.00%
Total consumption	4.69	1375	