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Auteurs

Laté Ayao Lawson, Phu Nguyen-Van

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BETA Université de Strasbourg
Faculté des sciences
économiques
et de gestion
61 avenue de la Forêt Noire
67085 Strasbourg Cedex
Tél. : +33 (0)3 68 85 20 69
Fax : +33 (0)3 68 85 20 70
Secrétariat : Géraldine Del Fabbro
g.delfabbro@unistra.fr

http://www.beta-umr7522.fr

Institutions and geography: A "two sides of the same coin" story of primary energy use in Sub-Saharan Africa

Laté Ayao Lawson, Phu Nguyen-Van*

BETA, CNRS, INRA & Université de Strasbourg, France

Abstract

Why do coastal located African countries seem more energies consuming? Do institutional and geographical factors matter to energy consumption as in the case of economic growth? Are there any spatial spillovers in primary energy use in Sub-Saharan Africa? To answer these questions which have been surprisingly few addressed in the existing literature, we empirically assess the link between energy use and economic growth in SSA, exploiting spatial data analysis methods. Our empirical results highlight the existence of positive spatial spillovers in primary energy use. We also derive factors (income, population dynamics and urbanization) explaining why coastal located countries are more energy intensive than inland ones. Furthermore, good political institutions encourage energy consumption, connoting a two side of the same coin phenomenon. Globally, our results impel African countries to develop alternative energies strategies and to deploy energy management policies, since increases in the demand for energies and related environmental consequences are expected in a near future.

Keywords: Energy, institutions, locational and spatial effects, development.

JEL Classification: C23, O55, Q43, Q56.

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*Corresponding author. Université de Strasbourg, BETA, 61 avenue de la Forêt Noire, 67000 Strasbourg, France. Tel: +33 368852039, E-mail: l.lawson@unistra.fr

1. Introduction

Recent acceleration of environmental degradation has alarmed international organizations and scientists about the future of the planet. This explains the establishment of agreements on environmental resources management as well as the implementation of several nature conservation policies. Thereby, researchers in economics have paid attention to the causes and consequences of environmental degradation, by studying issues such as deforestation, biodiversity loss, gas emissions, and energy consumption.

Works on economic growth and energy consumption represent a large part of the existing literature in energy economics, characterized by various focuses, methodological approaches and results. For a first group of researchers, it is a causality analysis. Considering energy to be an input in production activities, the quantity of energy used can reversely depend on income level.[1] For a second group, the aim is not only to carry out the direction of causality but also to identify the social and economic determinants of energy consumption, the energy and carbon dynamics, and furthermore to question the existence of an Environmental Kuznets Curve (EKC) for energy. The existence of such an EKC suggesting that related environmental issues, gas emissions for instance, likely reverse their trend in the process of development. The latter perspective is recently animated by researchers such as Akarca and Long (1979), Gallet and List (1999), Nguyen-Van (2010), Özokcu and Özdemir (2017), Antonakakis et al. (2017), to name but a few. While conflicting, this existing literature largely does not support the EKC hypothesis, concluding for a positive upward trend.[2]

Besides the social and economic drivers of energy demand, researchers have also questioned the channel through which energy availability improves economic development. On this, Toman and Jemelkova (2003) and Birol (2007) mentioned as outcomes of energy development, enhancement in health and education, and productivity increases in industrial and agricultural sectors. Regarding the main determinants of energy consumption, Medlock and Soligo (2001), Van Benthem and Romani (2009), Liddle (2013), Dogan and Turkekul

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[1] See on this Glasure and Lee (1998), Asafu-Adjaye (2000), Soytas and Sari (2003), Altinay and Karagol (2004), Lee (2005, 2006), Huang et al. (2008), and Joyeux and Ripple (2011) among others. Recent reviews of the causality analysis are presented in Huang et al. (2008) and Omri (2015)

[2] See the work by Tiba and Omri (2017) for a recent literature review on the EKC for energy consumption.

(2016), among others, pointed to income level, transportation, employment, population size, urbanization and end-use prices. In this literature, city enlargement appears to be closely tied to population growth and transportation, leading to increase in energy demand.

Regarding the specific case of Sub-Saharan Africa, henceforth SSA, the corresponding empirical findings do not contrast with the previous ones in terms of disparities. At country level for instance, the results by Odhiambo (2009a) point to the existence of a stable long-run relationship with a unilateral causality running from energy consumption to economic growth in Tanzania, while in South Africa there is a bidirectional causality (Odhiambo, 2009b). The conclusions by Ebohon (1996), Wolde-Rufael (2009) and Esso (2010) also support this bidirectional causality in Nigeria, Tanzania, Algeria, Benin, South Africa, and in Côte d'Ivoire. Akinlo (2008) provides country level analyses, suggesting a bidirectional causality in the Gambia, Ghana and Senegal, while no causality is observed in Cameroon, Cote d'Ivoire, Nigeria, Kenya and Togo. Similarly, Dogan (2014) found no-causality in Benin, Congo and Zimbabwe and unidirectional causality from energy use to income in Kenya. At regional level, Ouedraogo (2013) globally concludes for a long-run and causal relationship between energy consumption and economic growth in the 15 countries of the West African Economic Community, where the causality runs from GDP to energy consumption. There seems to be an interdependency between energy and income and the work by Kahsai et al. (2012) highlighted the role of income level in the causal relationship.

In addition, researchers also consider different aspects of the topic. For instance, the study by Kebede et al. (2010) points out regional disparities in energy demand, while Wesseh and Lin (2016) notice that capital, labor, renewable and non-renewable energies drive economic performance in Africa. Reversely, Eggoh et al. (2011) found a long-term link between energy consumption, real GDP, prices, labor and capital. Finally, it is to admit that this literature on SSA countries is characterized by the use of limited samples in addition to providing less evidence of an EKC. Surprisingly, no mention of the role of institution and geography cannot be identified in the literature on SSA. Indeed, primary energies representing a large part of energy consumed in SSA, a particular attention can be given to the its link to economic growth.

Being pre-industrial and highly natural resources depending economies, investigating issues relative to development, resources and primary energy use and its determinants in SSA seems pertinent. Moreover, the "Geography versus Institutions" debate mainly animated by Acemoglu et al. (2001, 2005, 2008) and Sachs (2003) and Sachs et al. (1999, 2001), to cite few, points out the importance of both factors in economic development. Accounting for this by introducing geographical factors, spatial interactions and political institutions in a study of the energy-income nexus in SSA appears to be promising, as such a research perspective seems poorly covered in the existing literature. Hence, we argue that institutions and geography, representing the "two sides of the same coin" in the comparative development debate, could play a similar role in energy consumption.

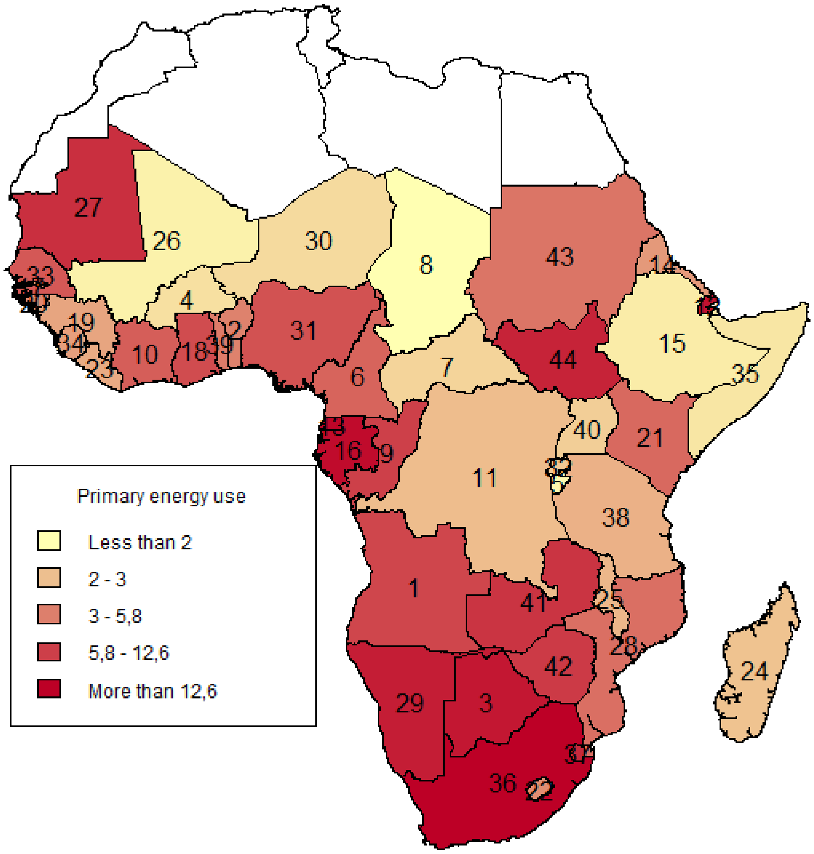

Figure 1: Primary energy use per capita, in thousandth of Kj.

Angola 1, Benin 2, Botswana 3, Burkina Faso 4, Burundi 5, Cameroon 6, Central African Rep. 7, Chad 8, Congo, Dem. Rep. 9, Congo, Rep. 10, Cote d'Ivoire 11, Djibouti 12, Equatorial Guinea 13, Eritrea 14, Ethiopia 15, Gabon 16, Gambia 17, Ghana 18, Guinea 19, Guinea-Bissau 20, Kenya 21, Lesotho 22, Liberia 23, Madagascar 24, Malawi 25, Mali 26, Mauritania 27, Mozambique 28, Namibia 29, Nigeria 30, Niger 31, Rwanda 32, Senegal 33, Sierra-Leone 34, Somalia 35, South Africa 36, Swaziland 37, Tanzania 38, Togo 39, Uganda 40, Zambia 41, Zimbabwe 42, Sudan 43, South Sudan 44.

To the best of our knowledge, there are very few studies on the income-primary energy nexus in SSA that account for location, political institutions and spatial interactions. This paper therefore, considering only primary energy use, innovates in investigating its link to income and population dynamics in SSA accounting for spatial interactions, geographical location and political institutions. Two main considerations motivate our analysis. First, observing Figure 1, one can claim that location matters to endowments in fossil energies as well as in primary energy use, since a relatively darker coloring is observed in coastal located countries. Also, looking from South to the North, it globally appears that countries with lower intensity in energy such as Chad, the Democratic Republic of Congo, Mali, and Ethiopia are mostly surrounded by countries with higher levels of energy consumption. There seems to be a spatial effect in primary energy use in SSA and, of course, its nature (positive or negative) is particularly relevant when analyzing the energy-income nexus. Alike the endowments, primary energy use is likely subject to spatial externalities among SSA neighboring countries, since geographically contiguous SSA countries show comparable endowments and further cooperate in the energy sector. Secondly, SSA countries being recently classified among the fastest growing economies, institutional and geographical factors seemingly play a significant role. Hence, our analysis focus on the primary energy and income link and proposes to account for political institutions and geography, arguing that both factors act as a "two sides of the same coin" effect on energy consumption, similarly to the case of economic growth.

The outline of the paper is as follows. Section 2 presents our data. Section 3 comprehensively describes the econometric approach in analyzing regression models relating primary energy use to its potential determinants. Section 4 presents and discusses the estimation results. In Section 5, we check the robustness of our results. Section 6 concludes our analysis.

2. Data and descriptive statistics

The literature on the energy-income link has identified besides income per capita potential drivers of energy demand such as population dynamics, urbanization and trade among others. Consequently, this empirical analysis uses series on GDP from the World Development Indicator (WDI) along with data on primary energy use obtained from the U.S. Energy Information Administration (EIA) and further control variable such as agricultural and industrial production, trade, population dynamics and political institutions.[3]

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[3] As proxy for political institutions, we rely on the WGI "Governance Effectiveness". The latter accounts for the quality of public services, policy formulation and implementation among others, and seems to be an excellent indicator for the quality of political organization in SSA countries.

Our main economic indicators are GDP per capita in purchasing power parity (PPP, in 2011 \$), the shares of trade, agriculture, and industry in GDP, and the rents of forest exploitation. As indicator of energy consumption, we consider the total primary energy use expressed in kilojoule (Kj) per capita. It is to admit that such a synthetic measure of primary energy consumption does not provide any information concerning its composition, neither on its renewable structure. However, it serves as a good proxy for fossil and biomass energies use in SSA. Because of missing values, the sample is reduced to 42 SSA countries, observed between 1990 and 2013.[4] Figure 1 helps identify Gabon, South-Africa and Nigeria as countries with the highest intensities of energy use per capita and respectively Chad, Mali and Ethiopia as presenting the lowest levels.

Table 1: Descriptive statistics

Variables	Units	Mean	S.D	Min	Max
lnGDP per capita	\$	7.60	0.89	5.51	10.83
lnEnergy use per capita	kilojoule	15.35	1.20	12.61	18.62
FDI, net inflows	% GDP	4.25	10.58	-82.89	161.82
Agriculture, added value	% GDP	28.06	17.02	0.89	78.65
Industry, added value	% GDP	27.26	15.80	3.33	84.28
Trade	% GDP	75.08	49.57	11.09	531.70
Urban population	% Pop	34.89	16.14	5.42	86.66
Population density	count/km^2	57.26	70.44	1.72	449.10
Forest rents	% GDP	7.81	8.63	.27	74.73
Institutions	index	-.77	.57	-1.98	.88

Notes: The sample includes $n = 42$ Sub-Saharan African countries.
Number of periods, $t = 24$. Total number of observations, N= 1008.

Table 1 reports descriptive statistics of the main series. Regarding income per capita, the highest values are observed in Equatorial Guinea, Gabon, South Africa and Botswana, where relatively high levels in energy consumption are also observed. Besides income per capita, agriculture, industry and trade share in GDP, we consider potential determinants such as FDI, urban population share, and population density. The highest levels in population density, 449.05 and 189.75 inhabitants per square kilometer (km^2), are respectively observed in Rwanda and Nigeria, while the lowest levels, 1.72 and 2.02 per km^2 are noticed in Namibia and Mauritania.

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[4] For South Sudan and Somalia, data are not available for the considered period.

3. Econometric model

Modeling spatial dependence, econometric textbooks such as Anselin (2013), Anselin and Arribas-Bel (2013), Arbia (2006, 2014), Baltagi (2003), and LeSage and Pace (2009), provide the convenient technical tools that exploit possible geographical links and weighting systems. Primary energies being essentially raw energies, we assume that the observations are processes with geographical characteristics and spillovers. This motivates the use of spatial regression techniques, accounting for time invariant and spatial effects, whose omission could bias our estimations.

Let $\omega_{(n\times n)}$ be a connectivity matrix (row standardized weighting system), the component of which are w_{ij} with $i, j = 1, 2 \dots n$, a general form of the spatial panel data model is:[5]

$$y_{it} = \mu_i + \rho\sum_{j=1}^{n} w_{ij} y'_{jt} + \sum_{j=1}^{n} w_{ij} x'_{jt}\beta_w + x'_{it}\beta + u_{it}, \text{ with } |\rho| < 1 \tag{1}$$

$$u_{it} = \delta\sum_{j=1}^{n} w_{ij} u_{jt} + \varepsilon_{it}, \text{ with } \varepsilon_{it}|x_{it} \sim iid(0, \sigma^2) \text{ and } |\delta| < 1 \tag{2}$$

where ρ, δ, β_w and β are the parameters to estimate, μ_i being the individuals time invariant effects.[6] The term $\sum_{j=1}^{n} w_{ij} y_{jt}$ stands for the spatial lag of the dependent variable and technically represents the average primary energy use in the neighboring countries, while $\sum_{j=1}^{n} w_{ij} u_{jt}$ and $\sum_{j=1}^{n} w_{ij} x_{jt}$ respectively stand for the spatial heterogeneity in residuals and the spatial lag of the vector of regressors. The parameter ρ technically captures the strength of the spatial dependence on the neighboring countries, if spatial spillovers there are in primary energy use. When specification tests (F test or wald test) suggest excluding the regressors' spatial lag, $\sum_{j=1}^{n} w_{ij} x_{jt}$, equations (1) and (2) become a model combining a spatial autoregressive model with spatially autocorrelated disturbances (SARAR). In that case, the regression model is reduced to:

$$y_{it} = \mu_i + \rho\sum_{j=1}^{n} w_{ij} y'_{jt} + x'_{it}\beta + u_{it} \text{ and } u_{it} = \delta\sum_{j=1}^{n} w_{ij} u_{jt} + \varepsilon_{it}, \tag{3}$$
$$\text{with } |\rho| < 1, \ |\delta| < 1 \text{ and } \varepsilon_{it}|x_{it} \sim iid(0, \sigma^2)$$

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[5] Different types of weighting systems can used. We rely in our estimations on a common border principle and on the k-nearest algorithm to build $\omega_{(n\times n)}$. See Tables A1 and A7 for more details.

[6] This is the general SARAR models (Arbia, 2014). Specification tests help find the form that corresponds to the DGP. (1) and (2) assume spatial autocorrelations only in the idiosyncratic term. Models where both, the error terms and individual effects, are spatially correlated are also feasible. See Kapoor et al. (2007).

The regression model (3) is the specification we use in the next section relating primary energy use to income per capita and other determinants.[7] Estimating ρ, δ, and the vector of parameters β, researchers such as Elhorst (2003, 2010), Baltagi et al. (2003, 2007), Kelejian and Prucha (1999) and Kapoor et al. (2007) propose maximum likelihood (ML) approaches based on several steps.[8] Discussing these ML strategies, Yu et al. (2008) and Debarsy and Ertur (2010) concluded that they provide consistent estimates. We thus estimate our model by using ML.

4. Estimation results and discussion

In this section, we use as weighting system a common borders based connectivity matrix, ω^*, (see Table A1). Before estimating the parameters, some specification tests are important.

4.1. Preliminary tests

Testing and modeling standard FE models

To begin, we perform standard Hausman test to compare FE to RE models for 4 different specifications. The test results in Table A2 indicate that the FE modeling consistently matches the data. Although very insightful, the estimated parameters of the FE models (see Table A3) likely suffer from several statistical problems, in particular from endogeneity related to the presence of GDP per capita among regressors. In the remaining, arguing that energy use is subject to spatial interactions, we test for the presence of spatial spillovers.

Testing the presence of spatial dependence

Tests for spatial dependence are performed in each of the 24 yearly waves of the dataset. The results of the latter tests (see Table A4) show some spatial lag dependence in primary energy use. Next, we consider the 4 different FE specifications mentioned above, testing for spatial dependence in energy use and in the residuals of each specification, by applying a robust LM test (Baltagi et al., 2007 and Anselin et al., 2013). The results support the presence of spatial spillovers in primary energies as well as some residuals spatial autocorrelation (see Table A5).

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[7] It is actually derived from specification tests, see Tables A4 and A5 for more details on the tests.

[8] A very comprehensive presentation of these estimation procedures is presented by Millo and Piras (2012).

Spatial Hausman and Wald tests

Accounting for the previous results, we perform the spatial Hausman and Wald tests, the latter inspecting whether the model should contain the spatial lag of the regressors, $\sum_{j=1}^{n} w_{ij} x_{jt}$. The spatial Hausman tests strengthen the rightness of a spatial FE modeling. In addition, we report in Table A5 the results comparing FE SARAR specifications to corresponding augmented models which include the spatial lag of the regressors.[9] The test statistics for the 4 different specifications broadly suggest that including $\sum_{j=1}^{n} w_{ij} x_{jt}$ does not significantly improve the quality of the regression. Hence, the FE SARAR model is the preferred model for our data. Nevertheless, we report the results of the augmented SARAR model in Appendix (see Table A6).

4.2. Results of estimating spatial FE models

Table 2 presents results of the FE SARAR model for primary energy use, combining ML techniques with instrumental variable method for regressor endogeneity. Indeed, the presence of GDP per capita among regressors creates a potential simultaneity. Therefore, at the first stage, taking advantage of the panel structure of the data, we regress GDP per capita on its lagged values and the remaining set of explanatory variables.[10] At the second stage, we apply a two-steps ML approach based on Baltagi et al. (2007) and Millo and Piras (2012) to estimate the parameters of the different specifications. Before discussing these results, it is useful to stress that the estimated parameters do not correspond to marginal effects, because of the presence of spatial interactions. Hence, for interpretation purpose, we compute the average direct and the total impacts for every determinants.

Analyzing $\hat{\rho}$ and $\hat{\delta}$, it appears that the FE SARAR specification suggested by the preliminary tests holds, as both spatial effects are statistically significant. The parameter $\hat{\rho}$ reflects spillovers from the neighboring countries in primary energy use. Nevertheless, as the amplitude of spatial spillovers can be related to the type of weighting system used, it should be carefully interpreted. Since ω^* simply indicates whether countries share a common

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[9] Thereby, we actually test the joint significance of the spatial lag of the regressors, $\sum_{j=1}^{n} w_{ij} x_{jt}$.

[10] The lagged GDP per capita, showing a correlation coefficient with current GDP per capita of circa 0.96, seems to be a good instrument. The predicted GDP per capita is used in the second stage.

boundary or not, it helps easily interpret the estimations results. Thus, $\hat{\rho}$ tells us how on average a country's own level of energy use depends on energy consumption in the neighboring countries, all things being equal. The observed positive result is strengthened by Figure 1, where each energy poor economy is surrounded by more energy intensive ones. It seems to us that cooperation among SSA countries in energy sectors and exchange in energy commodities (importations and exportations) constitute some of the main explanations of geographical spillovers in primary energy use. Based on this indication of geographical spillovers, our assertion relative to the role of geography in primary energy use in some instances holds.

Apart from the spatial spillovers, our study delivers further interesting results. The literature on energy consumption and economic growth has consistently concluded for a positive link between both factors. Our standard FE (see Table A3) and the FE SARAR models support this finding, besides the evidence of existence of spatial dependence in primary energy use. This implies that a steadily increasing primary energy use is to expect in SSA during the process of economic development. Controlling for the GDP shares of industry and agriculture in the regression analysis helps notice that industrial production activities, relatively to agriculture, is one of the most significant drivers of energy consumption in SSA. Even though at early stages of economic development, industrial activities, mainly consisting of mining and manufacturing activities, drive primary energy use in SSA.

To control for demographic dynamics, we rely on population density to find meaningful results. The estimated parameter of population density is negatively related to energy consumption. This negative link of population density to primary energy use per capita, previously suggested by the standard FE models, seems understandable as increases in total population, translated by positive changes in population density, should also dilute primary energy use measured in per capita terms. Indeed, increases in total population, thus in population density, lead to increases in the demand for energy and possibly to alternative energies consumption. For the considered period, population density meanly rises at a lower rate than energy demand, logically leading to a reduction in primary energy use in per capita terms. However, such an observation is not necessarily true when country level dynamics of energy demand and population are considered.[11] Further factors such as FDI and trade shares in GDP are found to be negatively related to energy use, suggesting that economic openness do not necessarily promote and increase primary energy use. With regard to trade share in GDP, a strong significant link to primary energy use appears, meaning that the more open SSA countries are to international trade, the less they rely on primary energies. The latter result on the link between trade openness and energy can probably be extended to other natural resources in SSA to mean that international trade of goods and service help countries to be less natural resources dependent.

Regarding political institutions, known in the existing literature as a positive determinants of economic growth (Acemoglu et al. 2005, 2008), they are expected to be positively affecting energy use, as GDP per capita does. Accordingly, our estimates show positive and statistically significant effects, implying that governance effectiveness, a good policy formulation and implementation can enhance the demand for primary energies. Obviously, not only good political institutions promote economic growth, they also directly appear to be enhancing the energy demand in SSA countries. In a context of environmental protection and emissions reduction, political actors are encouraged to develop alternative energy strategies and to find instruments that may help redirect the demand to renewable energies. Conclusively, our results so far indicate that besides geography, institutions appear not to be neutral in energy use. Indeed, geography and institutions do not only play a determinant role in economic development but also matter to primary energy use.

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[11] The RE model-V in Table A3, including urban population share sheds light on the role of demography in energy use, as the share of urban population shows a positive link to energy use. This implies that population growth and migration towards urban areas induce increases in urban population share and city enlargement. The latter finally intensify the energy demand and primary energy use in SSA.

Table 2: ML estimation of FE SARAR models of primary energy use

(a) Using the border based weighting matrix, ω_1

Covariates	I	II	III	IV
$\hat{\rho}$	.209** (.084)	.206** (.083)	.243***(.069)	.147*(.078)
$\hat{\delta}$	−.226** (.010)	−.223**(.103)	−.298**(.089)	−.199**(.096)
lnGDP per capita	.773***(.033)	.797***(.033)	.867***(.036)	.808***(.036)
Agriculture, GDP share		.002 (.002)	.003* (.002)	.001 (.002)
Industry, GDP share		.008***(.002)	.014***(.002)	.012***(.002)
Forest rents			.015***(.003)	.014***(.003)
Institutions			.744**(.078)	.698***(.080)
FDI				−.002* (.001)
Trade, GDP share				−.001***(.000)
Population density				−.003***(.000)
Number of Obs.	1008	1008	1008	1008
AIC Criterion	3582.444	3557.616	3473.170	3418.430
Log Likelihood	-1722.222	-1707.808	-1663.585	-1633.215
	Average direct impacts			
lnGDP per capita	.786***(.036)	.795***(.035)	.887***(.039)	.815***(.038)
Agriculture, GDP share		.002 (.002)	.004* (.002)	.001 (.002)
Industry, GDP share		.009***(.002)	.015***(.002)	.013***(.002)
Forest rents			.016***(.003)	.015***(.003)
Institutions			.761**(.079)	.705**(.080)
FDI				−.002*(.001)
Trade, GDP share				−.001***(.000)
Population density				−.003***(.000)
	Total impacts			
lnGDP per capita	.978***(.119)	.986***(.115)	1.146***(.122)	.946***(.103)
Agriculture, GDP share		.002 (.002)	.004 (.003)	.001 (.002)
Industry, GDP share		.012***(.003)	.019***(.003)	.015***(.003)
Forest rents			.020***(.004)	.017***(.004)
Institutions			0.984**(.140)	.818***(.123)
FDI				−.002*(.001)
Trade, GDP share				−.001***(.000)
Population density				−.004***(.001)

(b) Using the k-nearest algorithm based weighting matrix, ω_2

Covariates	I	II	III	IV
$\hat{\rho}$	.372***(.071)	.366***(.077)	.343***(.073)	.235**(.085)
$\hat{\delta}$	−.501***(.089)	−.448***(.129)	−.449***(.122)	−.291**(.127)
lnGDP per capita	.786***(.033)	.808***(.032)	.875***(.035)	.812***(.037)
Agriculture, GDP share		.002 (.002)	.003*(.002)	.001 (.002)
Industry, GDP share		.008***(.002)	.014***(.002)	.013***(.002)
Forest rents			.016***(.003)	.014***(.003)
Institutions			.722***(.078)	.688***(.039)
FDI				−.002*(.001)
Trade, GDP share				−.001***(.000)
Population density				−.003**(.001)
Number of Obs.	1008	1008	1008	1008
AIC Criterion	3569.650	3546.692	3467.892	3415.806
Log Likelihood	-1715.825	-1702.346	-1660.946	-1631.903
	Average direct impacts			
lnGDP per capita	.805***(.036)	.827***(.036)	.876***(.037)	.811***(.038)
Agriculture, GDP share		.002 (.002)	.004* (.002)	.001 (.002)
Industry, GDP share		.008***(.002)	.014***(.002)	.013***(.002)
Forest rents			.015***(.003)	.014***(.003)
Institutions			.723***(.080)	.688***(.083)
FDI				−.002*(.001)
Trade, GDP share				−.001***(.000)
Population density				−.003***(.001)
	Total impacts			
lnGDP per capita	1.252***(.171)	1.295***(.169)	1.333***(.169)	1.062***(.134)
Agriculture, GDP share		.003 (.003)	.005 (.003)	.001 (.003)
Industry, GDP share		.013***(.003)	.022***(.004)	.017***(.003)
Forest rents			.025***(.005)	.019***(.004)
Institutions			1.099***(.179)	.901***(.150)
FDI				−.002*(.001)
Trade, GDP share				−.002***(.000)
Population density				−.004***(.001)

Notes: Dependent variable is log primary energy use per capita. Standard errors derived from numerical Hessian estimation are in brackets. n=42 and T=24. $\hat{\rho}$ and $\hat{\delta}$ respectively stand for the spatial effects in primary energy use and in residuals. "***", "**" and "*" respectively indicate significance at 1%, 5% and 10% levels.

5. Robustness check, functional forms and the role of location

5.1. Robustness check based on a different weighting system

To check our results for robustness, from the preliminary tests up to the parameters of the FE SARAR models, we apply the same procedures as above but using a different weighting system. Thus, this section considers a distance-based weighting system which exploits the k-nearest neighboring algorithm, implying that even not directly contiguous countries could be considered as neighbors by the matrix entries (see Table A7).

The results using this second weighting matrix ω^{**} are presented in Table 2, panel b. Observing the preliminary tests, one first notices the following. Largely consistent with our previous results, the LM tests stress the importance of accounting for spatial dependences when modeling primary energy use. In addition, we compare spatial FE to RE model specifications. These spatial Hausman tests support our first conclusion regarding the suitability of a spatial FE modeling. Moreover, we perform Wald tests comparing restricted SARAR models to augmented ones, by testing the global significance of $\sum_{j=1}^{n} w_{ij}x_{jt}$. In this case, where we use the weighting system ω^{**}, the results in some extent suggest including the spatial lag of the explanatory variables into the SARAR models.[12] Given these test results, we estimate the parameter of model (3), with ω^{**} as weighting system, by using the same ML and instrumental variable as above.

The outcomes of estimating the parameters of the spatial FE models using ω^{**} (see Table 2, panel b) are globally consistent with the primer results, when considering the sign and the amplitude of the parameters. Nonetheless, the estimated spatial effects based on the weighting system ω^{**} take comparatively higher values, indicating stronger spatial spillovers in energy use. This is understandable since the two weighting matrices are quite different and ω^{**} shows an average number of links almost double that of ω^{*}. Regarding the determinants of energy use, the estimated parameters show values which almost equal those previously obtained, when considering GDP per capita, trade, agriculture and industry share in GDP and political institutions. The governance effectiveness index, alongside the geographical

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[12] As the results of the Wald tests somewhat advocate for including $\sum_{j=1}^{n} w_{ij}x_{jt}$, we report in the Appendix the results of estimating augmented models. See Table A6

effects represented by the spatial spillovers, shows once more a statistically significant link to primary energy use. Observing these second results, it definitely appears that our primer discussions and results interpretations thoroughly hold.

5.2. The links between primary energy use, income and urbanization

Apart from the robustness check, we test for linearities in the relationship between income, urban population share and primary energy use without controlling for other factors. The purpose of this exercise is to provide a general pattern of the link between these variables. Thereby, we rely on the local constant or Nadayara-Watson kernel estimator. This approach clarifies things by indicating an overall upward functional form between income per capita and primary energy use. Furthermore, such a result helps draw conclusions regarding the non existence of an EKC for primary energy use in SSA (see Figure 2).

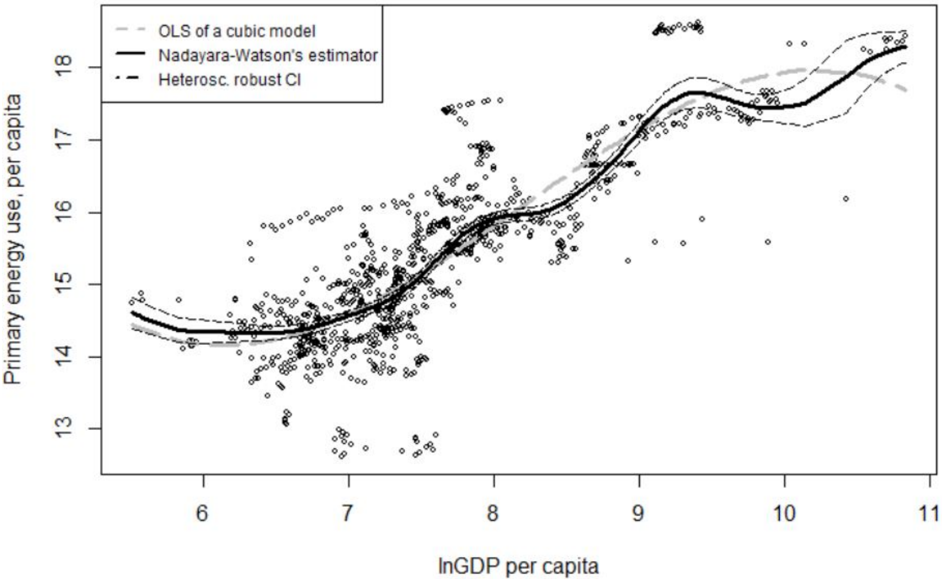

Figure 2: Pattern of the link between primary energy use and income

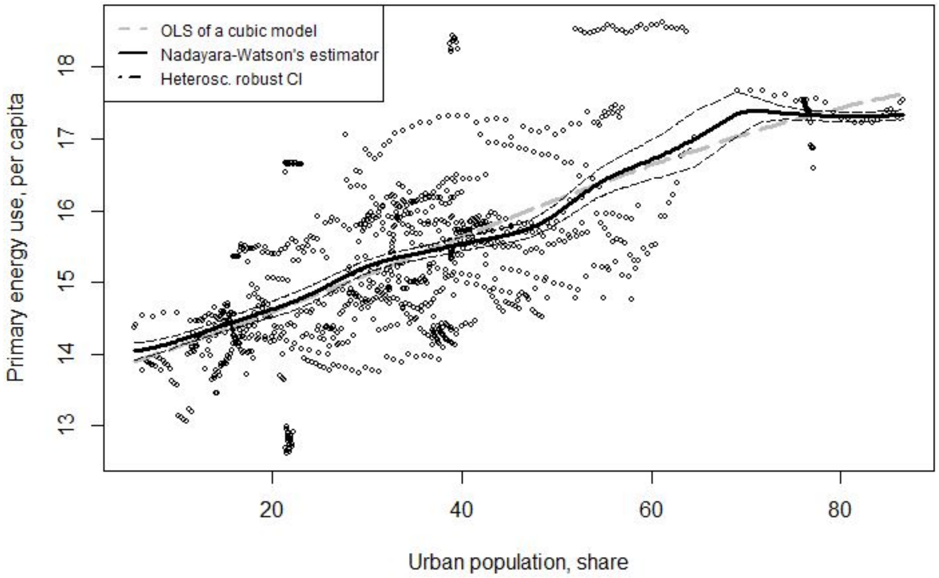

Figure 3: Pattern of the link between primary energy use and urban population

To closely investigate the general link between population dynamics, urbanization and primary energy consumption, it is quite informative to focus on urban population share in total population. This not only because parametric specification could be misleading but also because energy consumption being mainly an urban phenomenon in Africa (Mkhwanazi, 2003 and IEA, 2014), considering urban population dynamics should then help clarify the subject. Figure 3 shows an increasing pattern. For a share of urban population up to 60% a significantly clear upward trend in primary energy use appears. This result suggests that urbanization and related phenomena (city enlargement, and even more population growth) in SSA lead to increasing demand for energy. Consequently, increases in primary energy use are to expect in SSA where population growth is being observed.

5.3. Does location matter to primary energy use?

The evidence of spatial spillovers in primary energy use helps partly answer the question concerning the role of location. Observing that coastal located countries seems more energy intensive and further show relatively high income levels, we argue that location is not neutral in natural resources endowments and especially in primary energies. Hence, we explore the role of location, employing a dummy variable relative to coastal location. The results show that compared to inland countries, being a coastal located country positively and significantly affects primary energy use per capita by 0.44% (see Tables A8 and A3). Such a result is not surprising, as in average coastal located countries are also those where intense agricultural, mining and manufacturing activities are observed. As economic activities seem intensive in coastal located SSA countries, so does energy consumption. Thus, we can state that location matters not only to economic development but also to energy consumption. This corroborates our previous results on the role of geography, when geography-based spatial weighting systems are used. In summary, this robustness analysis supports our leading findings regarding not only the role of institutions and location, the existence of spatial spillovers in primary energy use, but also its main drivers.

6. Concluding remarks

The existing literature on the relationship between income and energy consumption has focused not only on the direction of causality but also on the EKC hypothesis for energy use, and further on the social and economic drivers of energy consumption. In SSA, where population and economic activities rapidly grow, the existing studies have raised questions regarding the determinants of energy use and future energy demands. However, issues related to spatial spillovers, institutional and geographical factors are much less investigated, contrarily to the growth literature.

Aiming to fill this gap by focusing only on primary energy use, this paper argues that in SSA countries geography and institutions matter to primary energy use. The latter seems highly related to economic activities, to demographic and social changes, and to regional cooperation, motivating a spatial analysis. By relying on the well known Institutions versus Geography debate with regard to their role in economic development, we identify both of these factors as important determinants of primary energy use.

The results support the existence of spatial spillovers in energy use among SSA countries, possibly induced by their cooperation in energy sectors. This highlights the role of geography in energy use, by suggesting that a country's own level in energy use is positively affected by primary energy use in the neighboring countries. In addition to the spatial interactions, SSA coastal located countries mostly showing high income level also appear to be relatively more energy intensive than inland one. Similar to geographical location, good political institutions are also found to be enhancing primary energy demand in SSA, illustrating a "two side of the same coin" role by institutions and geography.

Furthermore, our estimations show strong links of primary energy use to income per capita, population growth and to urban population share, implying that future economic performances and urbanization in SSA will lead to higher demands for energies. This is currently the case in South-Africa, Gabon, Equatorial Guinea and Ghana where economic performances and urbanization coincide with intensive primary energy use. As our sample is constituted by pre-industrial countries, thus low income countries, higher demand for energy and related environmental consequences such as pollutants emissions are to expect in a near future. On the role of population dynamics, as projections point to a fast population growth in the next 50 years, increases in demand for energy and a growing share of now-renewable energy consumption are also to expect, making Sustainable Development Goals more difficult to attain in SSA.

This study on primary energy use in SSA exploiting spatial regression approach has let some important points open to discussion and to possible improvements, especially concerning the environmental consequences of fossil and biomass energy use in pre-industrial economies. A further very insightful extension of this paper could be in purely investigating the primary energy consumption and carbon dynamics at early stages of development, by focusing on Sub-Sahara African countries. This is left to future researches.

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Appendix

Table A1: The border-based connectivity matrix 1, ω^*

1.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00
2.	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.00
3.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.25	0.25	0.00
4.	0.00	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.00	0.00	0.00	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.00	0.00	0.00	0.00
5.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00
6.	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.17	0.17	0.00	0.00	0.00	0.17	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.00	0.00	0.00	0.00	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7.	0.00	0.00	0.00	0.00	0.00	0.20	0.00	0.20	0.20	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20
8.	0.00	0.00	0.00	0.00	0.00	0.25	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25
9.	0.00	0.00	0.00	0.00	0.00	0.25	0.25	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.25	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10.	0.00	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.20	0.20	0.00	0.00	0.00	0.20	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11.	0.12	0.00	0.00	0.00	0.12	0.00	0.12	0.00	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.00	0.00	0.00	0.00	0.12	0.00	0.12	0.12	0.00	0.00
12.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.50	0.00	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13.	0.00	0.00	0.00	0.00	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.33	0.00	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33
15.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.25	0.00	0.00	0.0	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25
16.	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.33	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18.	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00
19.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.33	0.00	0.00	0.33	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.33	0.00	0.00	0.00
22.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.33	0.00	0.00
26.	0.00	0.00	0.00	0.17	0.00	0.00	0.00	0.00	0.00	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.00	0.00	0.17	0.00	0.00	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.14	0.14	0.00	0.00	0.14	0.14	0.00
29.	0.25	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.25	0.00	0.00
30.	0.00	0.20	0.00	0.20	0.00	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31.	0.00	0.25	0.00	0.00	0.00	0.25	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
32.	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.25	0.00	0.00	0.00
33.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.2	0.00	0.20	0.20	0.00	0.00	0.00	0.00	0.00	0.20	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
34.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.50	0.00	0.00	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
35.	0.00	0.00	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.17	0.00	0.00	0.00	0.00	0.00	0.17	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.00	0.00	0.00	0.00	0.17	0.00
36.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00
37.	0.00	0.00	0.00	0.00	0.12	0.00	0.00	0.00	0.00	0.00	0.12	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.12	0.00	0.00	0.00	0.12	0.00	0.00	0.12	0.00	0.00	0.00	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.12	0.00	0.00
38.	0.00	0.33	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
39.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.00
40.	0.12	0.00	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.00	0.00	0.12	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.00	0.00	0.00	0.12	0.00
41.	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.25	0.00	0.00
42.	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.17	0.00	0.00	0.00	0.00	0.00	0.17	0.17	0.00	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Notes: This matrix is based on common borders principle. Number of non-zero links: 167. Percentage non-zero weights: 9.46712. Average number of links: 3.97619

Table A2: Hausman test using standard FE and RE models

Hausman-test Stat.	χ^2	p-value	Number of regressors
Model I	12.375	.000	1
Model II	35.331	.000	3
Model III	21.950	.000	5
Model IV	123.970	.000	8

Notes: See Table A3 below for the variables involved in Models I-IV.

Table A3: Result of standard FE and RE models of primary energies use

Covariates/Models	**FE-I**	**FE-II**	**FE-III**	**FE-IV**	**RE-V**
lnGDP per capita	$.756^{***}$(.031)	$.760^{***}$(.031)	$.863^{***}$(.035)	$.841^{***}$(.036)	$.860^{***}$(.037)
Agriculture, value added		.002 (.002)	.003 (.002)	−.001 (.002)	.001 (.002)
Industry, value added		$.010^{***}$(.002)	$.015^{***}$(.002)	$.013^{***}$(.002)	$.013^{***}$(.002)
Forests rents			$.014^{***}$(.003)	$.012^{***}$(.003)	$.019^{***}$(.003)
Institutions			$.702^{***}$(.079)	$.599^{***}$(.082)	$.757^{***}$ (.082)
FDI, net inflows				−.002 (.001)	$-.002^{*}$ (.001)
Trade, GDP share				$-.001^{**}$(.000)	$-.002^{***}$(.000)
Population density				$-.002^{***}$(.000)	$-.003^{***}$(.001)
Urban population, share					$.012^{***}$(.003)
Coastal located, dummy					$.369^{**}$(.176)
Intercept					8.539^{***}(.315)
Observations	1008	1008	1008	1008	1008
F-stat (p-value)	587.575 (.000)	210.654 (.000)	152.274 (.000)	104.607 (.000)	100.644 (.000)
Adjusted R^2	.351	.368	.415	.439	.497

Notes: Dependent variable is log primary energy use p.c. See Table 3 for further comments. Robust standard errors are in brackets. "***", "**" and "*" respectively indicate significance at 1%, 5% and 10% levels. As instrument for GDP, we use its one year lag. For the location dummy, it takes 1 if coastal located, 0 otherwise.

Table A4: Test for spatial dependence in primary energy use considering yearly waves

	using ω^*		using ω^{**}	
Wave	Moran I	p-value	Moran I	p-value
Wave 1990	.047	.167	-.035	.538
Wave 1991	.026	.246	-.061	.631
Wave 1992	.019	.276	-.061	.628
Wave 1993	.023	.261	-.053	.602
Wave 1994	.005	.342	-.069	.658
Wave 1995	.011	.313	-.063	.638
Wave 1996	.002	.369	-.094	.733
Wave 1997	.006	.338	-.092	.728
Wave 1998	.016	.289	-.061	.629
Wave 1999	.037	.202	-.031	.520
Wave 2000	.047	.164	.006	.393
Wave 2001	.073	.094	.022	.339
Wave 2002	.047	.167	.094	.143
Wave 2003	.043	.179	.095	.142
Wave 2004	.076	.088	.058	.227
Wave 2005	.067	.108	.125	.090
Wave 2006	.073	.095	.121	.095
Wave 2007	.087	.065	.151	.058
Wave 2008	.111	.034	.169	.040
Wave 2009	.119	.026	.174	.037
Wave 2010	.134	.016	.198	.023
Wave 2011	.111	.033	.170	.040
Wave 2012	.097	.050	.156	.052
Wave 2013	.123	.024	.178	.034

Notes: Moran-I test under randomisation for primary energy use. H_0 is no spatial dependence. See Table 1 and 7 for details regarding the weighting systems ω^* and ω^{**}.

Table A5: Results of preliminary tests

		Using ω^*				Using ω^{**}		
Models	I	II	III	IV	I	II	III	IV
	LM tests for spatial dependence[a]				LM tests for spatial dependence [d]			
In primary energy	7.560 (.006)	16.259 (.000)	17.992 (.000)	19.221 (.000)	3.401 (.065)	2.872 (.090)	7.879 (.005)	14.829 (.000)
In residuals	.049 (.824)	4.269 (.038)	9.613 (.001)	17.214 (.000)	3.423 (.064)	17.575 (.000)	17.944 (.000)	29.042 (.000)
FE vs. RE	Spatial Hausman test[b]				Spatial Hausman test[e]			
χ^2	59.855	3.704	19.053	54.097	15.273	21.410	22.683	22.988
p-value	.000	.447	.004	.000	.000	.000	.000	.000
Wald tests	FE SARAR vs. SARAR augmented[c]				FE SARAR vs. SARAR augmented[f]			
χ^2	.128	2.891	4.794	15.776	.043	13.243	12.788	20.392
p-value	.720	.409	.442	.046	.836	.004	.052	.008

Notes: [b] Based on the results of standard Hausman tests, we perform locally robust LM tests for spatial lag and spatial error dependences. The statistics are the LM-stat and in brackets are the corresponding p-values.
[c]Based on the the spatial LM test results, we perform Hausman test comparing FE vs. RE SARAR models.
[d]The augmented model includes in addition to the regressors, their corresponding spatial lag. Wald tests compares both models and help clarify whether spatial lag of regressors should be introduced into the models.

Table A6: Augmented FE SARAR models of primary energy use

(a) Using the border based weighting matrix, ω^{*}

Covariates	**I**	**II**	**III**	**IV**
$\hat{\rho}$	$.209^{*}$ (.085)	$.201^{**}$(.085)	$.243^{***}$(.084)	$.143^{*}$(.078)
$\hat{\delta}$	$-.224^{*}$ (.104)	$-.210^{**}$(.105)	$-.307^{***}$(.089)	$-.203^{**}$(.088)
lnGDP per capita	$.772^{***}$(.033)	$.792^{***}$(.033)	$.867^{***}$(.036)	$.811^{***}$(.037)
Agriculture, GDP share		.002 (.002)	$.003^{*}$ (.002)	.001 (.002)
Industry, GDP share		$.009^{***}$(.002)	$.015^{***}$(.002)	$.013^{***}$(.002)
Forest rents			$.017^{***}$(.003)	$.015^{***}$(.003)
Institutions			$.743^{***}$(.078)	$.682^{***}$(.080)
FDI				$-.002^{*}$ (.001)
Trade, GDP share				$-.001^{***}$(.000)
Population density				$-.003^{***}$(.000)
Spatial lag.lnGDP per capita	.003 (.007)	.012(.010)	.014 (.011)	$.017^{*}$ (.010)
Spatial lag.Agriculture		$-.002^{*}$(.001)	$-.003^{*}$(.002)	$-.004^{*}$ (.002)
Spatial lag.Industry		$-.002$ (.001)	$-.002$ (.002)	$-.002$ (.002)
Spatial lag.Forest rents			$-.004$ (.025)	$-.000$ (.003)
Spatial lag.Institutions			$-.084^{*}$ (.036)	$-.061*$ (.036)
Spatial lag.FDI				$-.001$ (.002)
Spatial lag.Trade, GDP share				$-.004$ (.004)
Spatial lag.Population density				.001 (.002)
Number of obs.	1008	1008	1008	1008
Log likelihood	-1744.919	-1730.548	-1709.577	-1672.946

(b) Using the k-nearest algorithm based weighting matrix, ω^{**}

Covariates	**I**	**II**	**III**	**IV**
$\hat{\rho}$	$.354^{***}$(.076)	$.341^{***}$(.081)	$.340^{***}$(.071)	$.245^{**}$(.082)
$\hat{\delta}$	$-.458^{***}$(.011)	$-.415$ (.107)	$-.452^{***}$(.120)	$-.317^{**}$(.125)
lnGDP per capita	$.772^{***}$(.035)	$.815^{***}$(.036)	$.887^{***}$(.036)	$.823^{***}$(.037)
Agriculture, GDP share		.002 (.002)	$.004^{*}$ (.002)	.001 (.002)
Industry, GDP share		$.009^{***}$(.002)	$.015^{***}$(.002)	$.013^{***}$(.002)
Forest rents			$.015^{***}$(.003)	$.015^{***}$(.003)
Institutions			$.714^{***}$(.079)	$.685^{***}$(.081)
FDI				$-.002$ (.001)
Trade, GDP share				$-.001^{***}$(.000)
Population density				$-.003^{***}$(.000)
Spatial lag.lnGDP per capita	.005 (.024)	.049(.040)	$.108^{**}$(.042)	$.117^{**}$(.042)
Spatial lag.Agriculture		$-.003^{*}$ (.002)	$-.005^{*}$ (.003)	$-.004$ (.003)
Spatial lag.Industry		$-.007^{***}$(.002)	$-.007^{**}$(.003)	$-.006^{*}$ (.003)
Spatial lag.Forest rents			.006 (.004)	.005 (.004)
Spatial lag.Institutions			$.-047$ (.054)	$-.019$ (.053)
Spatial lag.FDI				.001 (.003)
Spatial lag.Trade, GDP share				$-.001$ (.001)
Spatial lag.Population density				$.001^{*}$ (.000)
Number of obs.	1008	1008	1008	1008
Log likelihood	-1739.828	-1721.261	-1654.618	-1624.656

Notes: Dependent variable is log primary energy use per capita. Standard errors derived from numerical Hessian estimation are in brackets. n=42 and T=24. $\hat{\rho}$ and $\hat{\delta}$ respectively stand for the spatial effects in primary energy use and in residuals. "***", "**" and "*" respectively indicate significance at 1%, 5% and 10% levels.

Table A7: The k-nearest algorithm based connectivity matrix 2, ω^{**}

1.	0.00	0.000	0.17	0.000	0.00	0.000	0.000	0.000	0.167	0.000	0.17	0.00	0.000	0.00	0.00	0.167	0.000	0.000	0.000	0.000	0.00	0.00	0.000	0.00	0.00	0.000	0.000	0.00	0.17	0.000	0.000	0.00	0.000	0.000	0.00	0.00	0.00	0.000	0.00	0.17	0.00	0.00
2.	0.00	0.000	0.00	0.091	0.00	0.091	0.000	0.000	0.000	0.091	0.00	0.00	0.091	0.00	0.00	0.000	0.000	0.091	0.091	0.000	0.00	0.00	0.091	0.00	0.00	0.091	0.000	0.00	0.00	0.091	0.091	0.00	0.000	0.000	0.00	0.00	0.00	0.091	0.00	0.00	0.00	0.00
3.	0.12	0.000	0.00	0.000	0.00	0.000	0.000	0.000	0.000	0.000	0.00	0.00	0.000	0.00	0.00	0.000	0.000	0.000	0.000	0.000	0.00	0.12	0.000	0.00	0.00	0.000	0.000	0.12	0.12	0.000	0.000	0.00	0.000	0.000	0.12	0.12	0.00	0.000	0.00	0.12	0.12	0.00
4.	0.00	0.071	0.00	0.000	0.00	0.000	0.000	0.000	0.000	0.071	0.00	0.00	0.000	0.00	0.00	0.000	0.071	0.071	0.071	0.071	0.00	0.00	0.071	0.00	0.00	0.071	0.071	0.00	0.00	0.071	0.071	0.00	0.071	0.071	0.00	0.00	0.00	0.071	0.00	0.00	0.00	0.00
5.	0.00	0.000	0.00	0.000	0.00	0.000	0.000	0.000	0.000	0.000	0.14	0.00	0.000	0.00	0.00	0.000	0.000	0.000	0.000	0.000	0.14	0.00	0.000	0.00	0.14	0.000	0.000	0.00	0.00	0.000	0.000	0.14	0.000	0.000	0.00	0.00	0.14	0.000	0.14	0.14	0.00	0.00
6.	0.00	0.111	0.00	0.000	0.00	0.000	0.111	0.111	0.111	0.000	0.00	0.00	0.111	0.00	0.00	0.111	0.000	0.000	0.000	0.000	0.00	0.00	0.000	0.00	0.00	0.000	0.000	0.00	0.00	0.111	0.111	0.00	0.000	0.000	0.00	0.00	0.00	0.111	0.00	0.00	0.00	0.00
7.	0.00	0.000	0.00	0.000	0.00	0.100	0.000	0.100	0.100	0.000	0.10	0.00	0.100	0.00	0.00	0.100	0.000	0.000	0.000	0.000	0.00	0.00	0.000	0.00	0.00	0.000	0.000	0.00	0.00	0.000	0.100	0.10	0.000	0.000	0.00	0.00	0.00	0.000	0.10	0.00	0.00	0.10
8.	0.00	0.000	0.00	0.000	0.00	0.200	0.200	0.000	0.000	0.000	0.00	0.00	0.000	0.00	0.00	0.000	0.000	0.000	0.000	0.000	0.00	0.00	0.000	0.00	0.00	0.000	0.000	0.00	0.00	0.200	0.200	0.00	0.000	0.000	0.00	0.00	0.00	0.000	0.00	0.00	0.00	0.20
9.	0.14	0.000	0.00	0.000	0.00	0.143	0.143	0.000	0.000	0.000	0.14	0.00	0.143	0.00	0.00	0.143	0.000	0.000	0.000	0.000	0.00	0.00	0.000	0.00	0.00	0.000	0.000	0.00	0.00	0.000	0.143	0.00	0.000	0.000	0.00	0.00	0.00	0.000	0.00	0.00	0.00	0.00
10.	0.00	0.091	0.00	0.091	0.00	0.000	0.000	0.000	0.000	0.000	0.00	0.00	0.000	0.00	0.00	0.000	0.091	0.091	0.091	0.091	0.00	0.00	0.091	0.00	0.00	0.091	0.000	0.00	0.00	0.000	0.000	0.00	0.091	0.091	0.00	0.00	0.00	0.091	0.00	0.00	0.00	0.00
11.	0.11	0.000	0.00	0.000	0.11	0.000	0.111	0.000	0.111	0.000	0.00	0.00	0.000	0.00	0.00	0.111	0.000	0.000	0.000	0.000	0.00	0.00	0.000	0.00	0.00	0.000	0.000	0.00	0.00	0.000	0.000	0.11	0.000	0.000	0.00	0.00	0.11	0.000	0.11	0.11	0.00	0.00
12.	0.00	0.000	0.00	0.000	0.00	0.000	0.000	0.000	0.000	0.000	0.00	0.00	0.000	0.25	0.25	0.000	0.000	0.000	0.000	0.000	0.25	0.00	0.000	0.00	0.00	0.000	0.000	0.00	0.00	0.000	0.000	0.00	0.000	0.000	0.00	0.00	0.00	0.000	0.00	0.00	0.00	0.25
13.	0.00	0.125	0.00	0.000	0.00	0.125	0.125	0.000	0.125	0.000	0.00	0.00	0.000	0.00	0.00	0.125	0.000	0.125	0.000	0.000	0.00	0.00	0.000	0.00	0.00	0.000	0.000	0.00	0.00	0.000	0.125	0.00	0.000	0.000	0.00	0.00	0.00	0.125	0.00	0.00	0.00	0.00
14.	0.00	0.000	0.00	0.000	0.00	0.000	0.000	0.000	0.000	0.000	0.00	0.33	0.000	0.00	0.33	0.000	0.000	0.000	0.000	0.000	0.00	0.00	0.000	0.00	0.00	0.000	0.000	0.00	0.00	0.000	0.000	0.00	0.000	0.000	0.00	0.00	0.00	0.000	0.00	0.00	0.00	0.33
15.	0.00	0.000	0.00	0.000	0.00	0.000	0.000	0.000	0.000	0.000	0.00	0.20	0.000	0.20	0.00	0.000	0.000	0.000	0.000	0.000	0.20	0.00	0.000	0.00	0.00	0.000	0.000	0.00	0.00	0.000	0.000	0.00	0.000	0.000	0.00	0.00	0.00	0.000	0.20	0.00	0.00	0.20
16.	0.14	0.000	0.00	0.000	0.00	0.143	0.143	0.000	0.143	0.000	0.14	0.00	0.143	0.00	0.00	0.000	0.000	0.000	0.000	0.000	0.00	0.00	0.000	0.00	0.00	0.000	0.000	0.00	0.00	0.000	0.143	0.00	0.000	0.000	0.00	0.00	0.00	0.000	0.00	0.00	0.00	0.00
17.	0.00	0.000	0.00	0.111	0.00	0.000	0.000	0.000	0.000	0.111	0.00	0.00	0.000	0.00	0.00	0.000	0.000	0.000	0.111	0.111	0.00	0.00	0.111	0.00	0.00	0.111	0.111	0.00	0.00	0.000	0.000	0.00	0.111	0.111	0.00	0.00	0.00	0.000	0.00	0.00	0.00	0.00
18.	0.00	0.100	0.00	0.100	0.00	0.000	0.000	0.000	0.000	0.100	0.00	0.00	0.100	0.00	0.00	0.000	0.000	0.000	0.100	0.000	0.00	0.00	0.100	0.00	0.00	0.100	0.000	0.00	0.00	0.000	0.100	0.00	0.000	0.100	0.00	0.00	0.00	0.100	0.00	0.00	0.00	0.00
19.	0.00	0.083	0.00	0.083	0.00	0.000	0.000	0.000	0.000	0.083	0.00	0.00	0.000	0.00	0.00	0.000	0.083	0.083	0.000	0.083	0.00	0.00	0.083	0.00	0.00	0.083	0.083	0.00	0.00	0.000	0.000	0.00	0.083	0.083	0.00	0.00	0.00	0.083	0.00	0.00	0.00	0.00
20.	0.00	0.000	0.00	0.111	0.00	0.000	0.000	0.000	0.000	0.111	0.00	0.00	0.000	0.00	0.00	0.000	0.111	0.000	0.111	0.000	0.00	0.00	0.111	0.00	0.00	0.111	0.111	0.00	0.00	0.000	0.000	0.00	0.111	0.111	0.00	0.00	0.00	0.000	0.00	0.00	0.00	0.00
21.	0.00	0.000	0.00	0.000	0.17	0.000	0.000	0.000	0.000	0.000	0.00	0.17	0.000	0.00	0.17	0.000	0.000	0.000	0.000	0.000	0.00	0.00	0.000	0.00	0.00	0.000	0.000	0.00	0.00	0.000	0.000	0.17	0.000	0.000	0.00	0.00	0.17	0.000	0.17	0.00	0.00	0.00
22.	0.00	0.000	0.20	0.000	0.00	0.000	0.000	0.000	0.000	0.000	0.00	0.00	0.000	0.00	0.00	0.000	0.000	0.000	0.000	0.000	0.00	0.00	0.000	0.00	0.00	0.000	0.000	0.00	0.20	0.000	0.000	0.00	0.000	0.000	0.20	0.20	0.00	0.000	0.00	0.00	0.20	0.00
23.	0.00	0.091	0.00	0.091	0.00	0.000	0.000	0.000	0.000	0.091	0.00	0.00	0.000	0.00	0.00	0.000	0.091	0.091	0.091	0.091	0.00	0.00	0.000	0.00	0.00	0.091	0.000	0.00	0.00	0.000	0.000	0.00	0.091	0.091	0.00	0.00	0.00	0.091	0.00	0.00	0.00	0.00
24.	0.00	0.000	0.00	0.000	0.00	0.000	0.000	0.000	0.000	0.000	0.00	0.00	0.000	0.00	0.00	0.000	0.000	0.000	0.000	0.000	0.00	0.00	0.000	0.00	0.50	0.000	0.000	0.50	0.00	0.000	0.000	0.00	0.000	0.000	0.00	0.00	0.00	0.000	0.00	0.00	0.00	0.00
25.	0.00	0.000	0.00	0.000	0.14	0.000	0.000	0.000	0.000	0.000	0.00	0.00	0.000	0.00	0.00	0.000	0.000	0.000	0.000	0.000	0.00	0.00	0.000	0.14	0.00	0.000	0.000	0.14	0.00	0.000	0.000	0.14	0.000	0.000	0.00	0.00	0.14	0.000	0.00	0.14	0.14	0.00
26.	0.00	0.077	0.00	0.077	0.00	0.000	0.000	0.000	0.000	0.077	0.00	0.00	0.000	0.00	0.00	0.000	0.077	0.077	0.077	0.077	0.00	0.00	0.077	0.00	0.00	0.000	0.077	0.00	0.00	0.077	0.000	0.00	0.077	0.077	0.00	0.00	0.00	0.077	0.00	0.00	0.00	0.00
27.	0.00	0.000	0.00	0.143	0.00	0.000	0.000	0.000	0.000	0.000	0.00	0.00	0.000	0.00	0.00	0.000	0.143	0.000	0.143	0.143	0.00	0.00	0.000	0.00	0.00	0.143	0.000	0.00	0.00	0.000	0.000	0.00	0.143	0.143	0.00	0.00	0.00	0.000	0.00	0.00	0.00	0.00
28.	0.00	0.000	0.14	0.000	0.00	0.000	0.000	0.000	0.000	0.000	0.00	0.00	0.000	0.00	0.00	0.000	0.000	0.000	0.000	0.000	0.00	0.00	0.000	0.14	0.14	0.000	0.000	0.00	0.00	0.000	0.000	0.00	0.000	0.000	0.00	0.14	0.14	0.000	0.00	0.14	0.14	0.00
29.	0.17	0.000	0.17	0.000	0.00	0.000	0.000	0.000	0.000	0.000	0.00	0.00	0.000	0.00	0.00	0.000	0.000	0.000	0.000	0.000	0.00	0.17	0.000	0.00	0.00	0.000	0.000	0.00	0.00	0.000	0.000	0.00	0.000	0.000	0.17	0.00	0.00	0.000	0.00	0.17	0.17	0.00
30.	0.00	0.143	0.00	0.143	0.00	0.143	0.000	0.143	0.000	0.000	0.00	0.00	0.000	0.00	0.00	0.000	0.000	0.000	0.000	0.000	0.00	0.00	0.000	0.00	0.00	0.143	0.000	0.00	0.00	0.000	0.143	0.00	0.000	0.000	0.00	0.00	0.00	0.143	0.00	0.00	0.00	0.00
31.	0.00	0.091	0.00	0.091	0.00	0.091	0.091	0.091	0.091	0.000	0.00	0.00	0.091	0.00	0.00	0.091	0.000	0.091	0.000	0.000	0.00	0.00	0.000	0.00	0.00	0.000	0.000	0.00	0.00	0.091	0.000	0.00	0.000	0.000	0.00	0.00	0.00	0.091	0.00	0.00	0.00	0.00
32.	0.00	0.000	0.00	0.000	0.12	0.000	0.125	0.000	0.000	0.000	0.12	0.00	0.000	0.00	0.00	0.000	0.000	0.000	0.000	0.000	0.12	0.00	0.000	0.00	0.12	0.000	0.000	0.00	0.00	0.000	0.000	0.00	0.000	0.000	0.00	0.00	0.12	0.000	0.12	0.12	0.00	0.00
33.	0.00	0.000	0.00	0.111	0.00	0.000	0.000	0.000	0.000	0.111	0.00	0.00	0.000	0.00	0.00	0.000	0.111	0.000	0.111	0.111	0.00	0.00	0.111	0.00	0.00	0.111	0.111	0.00	0.00	0.000	0.000	0.00	0.000	0.111	0.00	0.00	0.00	0.000	0.00	0.00	0.00	0.00
34.	0.00	0.000	0.00	0.091	0.00	0.000	0.000	0.000	0.000	0.091	0.00	0.00	0.000	0.00	0.00	0.000	0.091	0.091	0.091	0.091	0.00	0.00	0.091	0.00	0.00	0.091	0.091	0.00	0.00	0.000	0.000	0.00	0.091	0.000	0.00	0.00	0.00	0.091	0.00	0.00	0.00	0.00
35.	0.00	0.000	0.20	0.000	0.00	0.000	0.000	0.000	0.000	0.000	0.00	0.00	0.000	0.00	0.00	0.000	0.000	0.000	0.000	0.000	0.00	0.20	0.000	0.00	0.00	0.000	0.000	0.00	0.20	0.000	0.000	0.00	0.000	0.000	0.00	0.20	0.00	0.000	0.00	0.00	0.20	0.00
36.	0.00	0.000	0.20	0.000	0.00	0.000	0.000	0.000	0.000	0.000	0.00	0.00	0.000	0.00	0.00	0.000	0.000	0.000	0.000	0.000	0.00	0.20	0.000	0.00	0.00	0.000	0.000	0.20	0.00	0.000	0.000	0.00	0.000	0.000	0.20	0.00	0.00	0.000	0.00	0.00	0.20	0.00
37.	0.00	0.000	0.00	0.000	0.12	0.000	0.000	0.000	0.000	0.000	0.12	0.00	0.000	0.00	0.00	0.000	0.000	0.000	0.000	0.000	0.12	0.00	0.000	0.00	0.12	0.000	0.000	0.12	0.00	0.000	0.000	0.12	0.000	0.000	0.00	0.00	0.00	0.000	0.12	0.12	0.00	0.00
38.	0.00	0.083	0.00	0.083	0.00	0.083	0.000	0.000	0.000	0.083	0.00	0.00	0.083	0.00	0.00	0.000	0.000	0.083	0.083	0.000	0.00	0.00	0.083	0.00	0.00	0.083	0.000	0.00	0.00	0.083	0.083	0.00	0.000	0.083	0.00	0.00	0.00	0.000	0.00	0.00	0.00	0.00
39.	0.00	0.000	0.00	0.000	0.14	0.000	0.143	0.000	0.000	0.000	0.14	0.00	0.000	0.00	0.14	0.000	0.000	0.000	0.000	0.000	0.14	0.00	0.000	0.00	0.00	0.000	0.000	0.00	0.00	0.000	0.000	0.14	0.000	0.000	0.00	0.00	0.14	0.000	0.00	0.00	0.00	0.00
40.	0.10	0.000	0.10	0.000	0.10	0.000	0.000	0.000	0.000	0.000	0.10	0.00	0.000	0.00	0.00	0.000	0.000	0.000	0.000	0.000	0.00	0.00	0.000	0.00	0.10	0.000	0.000	0.10	0.10	0.000	0.000	0.10	0.000	0.000	0.00	0.00	0.10	0.000	0.00	0.00	0.10	0.00
41.	0.00	0.000	0.12	0.000	0.00	0.000	0.000	0.000	0.000	0.000	0.00	0.00	0.000	0.00	0.00	0.000	0.000	0.000	0.000	0.000	0.00	0.12	0.000	0.00	0.12	0.000	0.000	0.12	0.12	0.000	0.000	0.00	0.000	0.000	0.12	0.12	0.00	0.000	0.00	0.12	0.00	0.00
42.	0.00	0.000	0.00	0.000	0.00	0.000	0.200	0.200	0.000	0.000	0.00	0.20	0.000	0.20	0.20	0.000	0.000	0.000	0.000	0.000	0.00	0.00	0.000	0.00	0.00	0.000	0.000	0.00	0.00	0.000	0.000	0.00	0.000	0.000	0.00	0.00	0.00	0.000	0.00	0.00	0.00	0.00

Notes: This matrix is built considering the k-nearest neighboring countries, with k=2. Number of countries = 42.

Number of non-zero links: 334. Percentage non-zero weights: 18.93424. Average number of links: 7.952381

Table A8: Energy-Income and Energy-Urban population nexus

Covariate/Models	VI	VII	VIII
Intercept	7.579***(.178)	70.647***(6.277)	58.080***(5.906)
Coastal located, dummy	.610***(.043)	.608***(.042)	.419***(.004)
Institutions	.558***(.074)	.783***(.074)	.881***(.007)
lnGDP per capita	1.028***(.024)	−21.949***(2.347)	−16.913***(2.216)
Squared lnGDP per capita		2.757***(.290)	2.106***(.274)
Cubic lnGDP per capita		−.109***(.012)	−.082***(.012)
Urban population share			−.020 (.013)
Squared urban pop. share			.001***(.000)
Cubic urban pop. share			-.009***(.002)
Adj. R-squared:	.727	.755	.792
F-stat. (*p*-value)	896.907 (.000)	622.535 (.000)	479.821 (.000)

Notes: The dependent variable is log primary energy use p.c. n=42 and T=24. In brackets are robust standard errors. Models estimated pooling the observations. For the location dummy, 1 if coastal located.