

ORIGINAL ARTICLE

Open Access



Democratic institutions and the energy intensity of well-being: a cross-national study

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Abstract

Background: Energy consumption is necessary for human well-being, yet the growth of energy consumption also contributes to climate change and a range of negative externalities. Thus, a key sustainability challenge is to efficiently use energy consumption to promote human well-being. This manuscript contributes to the growing literature on the ecological intensity of well-being (EIWB) by modeling the relationship between democratic institutions and the energy intensity of well-being.

Methods: We use international data to understand how democratic institutions—understood as a combination of elected legislature, elected executives, and democratic competition—impact the energy intensity of well-being. The energy intensity of well-being is an adjusted ratio of energy consumption and life expectancy. We combine random-intercept mixed-effect models with entropy balancing constraints to create covariate balance between democracies and non-democracies.

Results: Contrary to our expectations, we find that consistently null results suggesting that democracies do not leverage their energy consumption to improve well-being more effectively than other systems of government. Democracy and its subcomponents do not appear to improve, or reduce, the energy intensity of well-being.

Conclusions: Democracy does not appear to improve sustainability, operationalized as the energy intensity of well-being. On the other hand, democracies do not appear to do worse than non-democracies, suggesting democratization can spread without reducing sustainability.

Keywords: Democracy, Causal inference, Energy consumption, Sustainable development

Background

The advent of modern forms of energy production—such as the burning of fossil fuels like coal and oil—in tandem with other technological changes helped usher in a rapid increase in standard of living in many parts of the world [1]. Before the rise of industrialized energy production, life expectancy and many other indicators of well-being had remained stagnant throughout much of human history. Hence, the widespread growth in the production and consumption of energy—as well as contemporaneous changes like the decline in deaths due to contagious disease—has been a key contributor to improving worldwide living standards, economic development, and the general advance of civilization [2, 3].

Energy is widely recognized as a prerequisite to modern lifestyles, economic development, and human development [4–7]. However, scholars have expressed grave concerns about the long-run sustainability of rapid population growth and rising quality of life since the work of Malthus [8] and Jevons [9].

While Malthus, Jevons, and more contemporary observers (e.g., [10, 11]) have focused primarily on issues of depletion and scarcity, it is important to note that rapid growth in energy usage has also engendered a range of negative externalities. Energy production, particularly from fossil fuels, has reduced air quality and threatened public health around the world. Public health impacts of energy production include reduced cognitive ability [12]—especially among children via low birth weight [13, 14]—cancer [15, 16], asthma [17], and many

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other health maladies (e.g., [18, 19]). Secondly, energy production often requires a large land footprint, reducing wildlife habitat, threatening biodiversity, and otherwise destroying culturally valued landscapes [20–22]. Indeed, in extreme situations, the quest for energy might render entire regions uninhabitable—infamous cases include Chernobyl and Centralia, Pennsylvania in the USA. Energy production and consumption, therefore, presents a paradox—it is both vital for human well-being while simultaneously a threat to human well-being. Hence, it is critically important to understand how well-being relates to energy consumption, and how energy might be used more efficiently to increase well-being.

The purpose of this paper is to extend the literature on the ecological intensity of human well-being (e.g., [23]) by considering the case and the energy intensity of well-being (hereafter “EIWB”). Below, we argue that this framework provides a unique perspective on how to capture the complex interplay between well-being and energy consumption cross-nationally. We suggest that one potential contributor to cross-national variation in EIWB relates to political institutions—that is, we expect that democracies are able to leverage their energy consumption more effectively to improve human well-being.

This analysis makes several contributions to the literature. First, this is one of the few studies of the energy intensity of well-being (for exceptions, see [24] and [25]). Secondly, we rely on more nuanced indicators of democracy than much of the prior literature [26]. More significantly, we use novel counterfactual methods—in our case, an algorithmic approach called entropy balancing—to improve causal inference in the ecological intensity of human well-being literature.

Literature review

Energy consumption and well-being

Social scientists have long been interested in the relationship between well-being (broadly construed) and energy consumption, but despite long-standing interest, there are surprisingly few studies that have empirically documented this relationship. Generally, this research finds that energy consumption (or carbon emissions) is tightly linked to well-being at lower levels of economic development, often employing models informed by the IPAT or Kaya identity framework. However, for high-income nations, energy consumption and emissions tend to decouple from well-being such that growth in energy consumption does not necessarily improve well-being in high-income nations [4, 27–36]. Pasternak [33] refers to this phenomenon as a “plateau,” while Martinez and Ebenhack [36] offer the term “saturation”. While the estimates vary, the “saturation” point where additional energy consumption does

not increase well-being appears to be startlingly low. Goldemberg et al. [37] suggests that this figure around 1 kW per capita can provide “basic needs,” while Spreng [38] proposed a “2000-watt society”. Steinberger and Roberts [39] argue that saturation point has changed over time, such that current technologies allow much greater well-being at low levels of energy consumption from the period of 1975 to 2005. They demonstrate that in 2005, about 40 GJ or around 1 mt of CO₂ per capita can produce very high scores on many indicators of human development, such as life expectancy. Many other studies have pointed to the need to empirically assess the degree of environmental impacts—in the form of energy consumption, production, or emissions—necessary to sustain a decent standard of living [7, 40].¹ Overall, the small body of prior literature strongly suggests that energy consumption far below that typical in developed nations can be sufficient to produce high levels of well-being.

Ecological intensity of human well-being

A related but distinct body of literature has considered the environmental efficiency of well-being, also referred to as the ecological intensity of well-being. Research in this tradition argues that it provides a useful operationalization of the notoriously elusive concept of “sustainability.” In this tradition, sustainability is operationalized as the ratio of well-being to environmental degradation. In their foundational paper, Dietz, Rosa, and York [23] write:

“...it might be fruitful to investigate how nations differ in the amount of well-being they create for each unit of environmental stress they produce. That is, it may be appropriate to move from looking just at environmental “bads” to looking at what “goods” nations manage to produce from stressing the environment.” (pg. 116) [23].

Ecological intensity of well-being research is inspired by the concept of energy intensity, typically understood as the total energy consumption of a country divided by its gross domestic product. Ecological intensity of well-being departs from this approach by considering the ratio of country-level environmental impacts and some indicator of human well-being—such as life expectancy. For instance, [41] and [42] operationalize ecological intensity of well-being by using ecological footprints and life expectancy, [43, 44] and [45] employ carbon dioxide emissions per capita and life expectancy, while [24] and [25] rely on the ratio of energy consumption and life expectancy. On the other hand, [46] prefer to use the ratio of ecological footprints and average life satisfaction—an indicator of subjective well-being.

Though the measurements vary, ecological intensity of well-being indicators is advantageous over other methods of operationalizing sustainability. More common methods of quantifying sustainability rely on single or composite measures of environmental impact, emissions, pollution, or ecosystem damage—such as the ecological footprints [47] or greenhouse gas emissions [48]. However, given that human well-being is coupled with natural systems in complex ways [49–51], an alternative approach to conceptualizing sustainability focusses on how humans can flourish with minimal ecological impact [23]. This approach is especially apt for energy consumption because, as we noted in the introduction, energy consumption both reduces human well-being via negative externalities while it also forms the bedrock for human flourishing. Thus, understanding how to minimize energy consumption while maximizing well-being is a critical question. In the next section, we review the literature on political institutions and the environment, focusing on the role of democracy in explaining cross-national variation in environmental outcomes.

Political institutions and sustainability

The relationship between political institutions—particularly democracy and democratization—and environmental outcomes at the national level has been given considerable attention by scholars over the last half-century. Indeed, in their widely cited review, Rosa and Dietz [52] identify institutions as a key driver of national greenhouse gas emissions. This diverse, multi-disciplinary collection of studies is informed by different theoretical perspectives. Typically, political scientists and economists have favored a perspective that alludes to rational choice arguments or arguments whose core notions parallels ecological modernization theory. Briefly, these viewpoints tend to suggest that democratization should improve environmental quality. Rational choice perspectives focus on the incentives faced by democracies. In democracies, citizens might express their preferences for environmental quality via voting while dictators have short time horizons and are often reliant on natural resources to bolster their tenuous grip on power [53, 54]. Further, dictators might encourage rapid natural resource development, particularly resource extraction, to reward parties loyal to the regime [55, 56]. While the details are not identical, ecological modernization theorists also view democracy as a positive for environmental quality, primarily because democracies can more effectively pursue “ecological rationalization” via carefully designed policy and lifestyle change [57–59]. Hence, significant theoretical perspectives suggest that, as democracies become more developed, resources should be used more efficiently and societies should become more sustainable.

The empirical literature paints a mixed picture, but overall, it seems to suggest that democracies fare better

environmentally than dictatorships across a range of outcomes. Mather, Needle, and Fairburn [60] report that democracy reduces deforestation, and several studies have found that democracies tend to have lower carbon dioxide emissions [61–66]. Democracies also have lower sulfur dioxide emissions [67–69], tend to have cleaner water [65, 69], and improved biodiversity [70]. In contrast, other research has found that democracies have higher rates of deforestation [71–73] and lower water quality [74].

Most of these papers have relied upon a few different sources for indicators of democracy. These include the Polity2 variable from the Policy IV data [75, 76], the Freedom House indicators [72, 74], the indicators developed by the Economist magazine, or some combination [77]. This class of indicators is extremely useful, especially because they provide a single variable that summarizes institutional conditions within a given nation at a certain point in time. These indicators can provide relatively straightforward answers about the role of democracy (or lack thereof) in environmental problems.

However, their advantage is also their drawback. Nations with similar levels of democracy, as captured by indicators like Polity2 or the Freedom House variables, can still exhibit substantial variation in terms of their system of government. That is, democracies are not equivalent across all institutional characteristics and the most popular indicators might miss some key nuances. To this end, Cheibub, Gandhi, and Vreeland [26] provide a novel set of indicators informed by a multi-faceted conceptualization of democracy. Drawing upon diverse theorizations of democracy, they argue that it has four primary features: (1) the chief executive (i.e., prime minister or president) must be popularly elected or appointed by an elected body, (2) the legislature must be popularly elected, (3) there must be multiple, competing political parties, and (4) incumbent chief executives must be replaced by elections governed by the same procedures by which they were initially elected. Below, we explain how these indicators were combined with causal inference methods for observational data to understand the relationship between democracy and EIWB.

Methods

Dependent variable

Our dependent variable is a ratio of energy use per capita (measured as a kilogram of oil equivalent) and life expectancy at birth in years, both variables were obtained from the World Bank database using the *db worldbank* Stata plug-in [78]. Using a ratio as a dependent variable creates a unique complication because the ratio can be dominated by either the numerator or denominator. The root of this problem is that the range and variation of both variables can differ quite markedly. Indeed, for the valid cases used

in the models below life expectancy ranges from 41 to 83 with a standard deviation of 9 and a coefficient of variation of 0.12. Energy use per capita ranges from 59 to 22,762 with a standard deviation of 2533 and a coefficient of variation of 1. Hence, there is much variation in both life expectancy and energy use per capita, but comparatively more variation in energy use. Energy use per capita, therefore, will inflate the variation in the ratio.

Fortunately, a widely accepted method has been developed to address this significant problem. The resolution involves equalizing the coefficient of variation for the numerator (in our case, energy use per capita) and coefficient of variation for the denominator (life expectancy) by adding a constant to the numerator, thereby shifting the mean without altering the variance [24, 41, 43]. For our variables, the coefficient of variation can be equalized to the fourth decimal place by adding 17,737 to energy use per capita. After performing this transformation, we multiply the ratio by 100 to facilitate more straightforward interpretation of our modeling results. This calculation can be expressed as:

$$EIWB = \frac{[(\text{Energy Consumption per capita} + 17737)]}{\text{Life Expectancy} \times 100}$$

Figure 1 provides annual averages and interquartile range for our energy intensity of well-being (EIWB) variable from 1990 to 2008, the period under analysis. Overall, EIWB has remained relatively stable over this period, though the trend seems to be towards reduced energy intensity of well-being.

Binary treatments for democratic characteristics

We constructed a series of binary variables to isolate different characteristics of democracy as defined in the

Democracy-Dictatorship dataset developed by [26]. For the sake of parsimony and to facilitate causal inference methods, we dichotomize several multiple-category indicators.

These include the *exselec* indicator for mode of executive selection. The original variable was scored with three categories for direct popular election, indirect election (i.e., selection of the executive by an elected assembly), and non-elected executive. This variable was transformed to isolate nations with elected executives (0 = non-elected legislature, 1 = indirect or direct election). Next, we use a variable to identify nations with an elected legislature, recoded from the *legselec* variable in the original data. The recoded variable is scored such that countries without a legislature or with a non-elected legislature are coded with a “0” and nations with an elected legislature are coded with a “1”. Then, we used the *defacto* indicator to capture political competition. We group together nations with no parties or one party into the “0” category, and multiple parties are coded as a “1”. Finally, we created a binary indicator for a “full” democracy where a given country has the combination of an elected executive, an elected legislature, and competing political parties.

Control variables

An array of factors has been demonstrated to influence national-level environmental outcomes. Chief among these is economic development, where studies consistently show that economic growth is associated with higher greenhouse gas emissions [79–82] and ecological footprints [83, 84]. Some, but not all, analyses find a non-linear relationship between economic development and ecological degradation whereby economic growth increases degradation for low-income countries but improves environmental performance for high-income countries [85–88]—this inverted U-shaped relationship has been dubbed the “environmental Kuznets curve.” More specific to the ecological intensity of well-being, Dietz, Rosa, and York [41] find evidence against the environmental Kuznets curve. Operationalizing ecological intensity of well-being as the ratio of ecological footprints to life expectancy, the authors observe a U-shaped relationship between the ecological intensity of well-being and development. Here, we include GDP per capita in thousands of 2011 US dollars adjusted for purchasing power parity.² In keeping with standard modeling conventions, we also include a quadratic term for GDP per capita and take the natural log of both variables.

International trade has also been identified as an important driver of environmental outcomes, with nuanced effects that vary across nations [83, 89–92]. Accordingly, we include a control variable for exports as a percentage of GDP. Nations with larger militaries tend to have lower environmental performance than their counterparts [72, 83, 93], and we control for military expenditures as a percentage of GDP to capture this influence. To capture urbanization, we

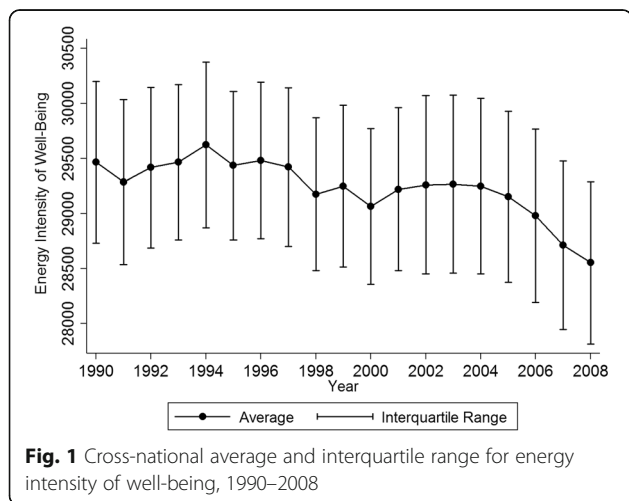


Fig. 1 Cross-national average and interquartile range for energy intensity of well-being, 1990–2008

use the percentage of national population living in an urban setting. Finally, because this analysis is focused on the energy intensity of well-being, we use an indicator of the percentage of energy consumption from renewable sources. As with our dependent variable, all data for control variables was accessed via the *db worldbank* Stata plug-in for the World Bank's online database [78]. Our merged dataset covers the years 1990–2008. Descriptive statistics for the control and democracy treatment variables are provided in Table 1.

Statistical methods

Causal inference

In addition to employing novel indicators of democracy, we also seek to improve causal inference in cross-national studies. Experimental manipulation where cases are randomly assigned to the treatment and control condition is widely considered the “gold standard” of causal inference—that is, randomization produces the strongest evidence of causation. More technically, randomization of treatment status creates a condition called statistical equivalence (alternatively known as “covariate balance”). Covariate balance is a condition in which the treatment and control groups are equivalent on all variables, both unobserved and observed, in terms of descriptive statistics such as the mean or standard deviation. Observational studies, on the other hand, rely on data that does not include randomization of treatment assignment and estimates derived from observational data, such as regression coefficients, cannot be considered strictly causal. Typically, observational studies suffer from self-selection problems whereby characteristics of cases determine their selection into the treatment or control status. This problem is evident in our dataset as democracies differ from non-democracies on a range of variables. A further complication to identifying the causal impact of institutional conditions is rooted in their relative stability. For

instance, few countries are apt to change from a non-elected legislature to an elected legislature over several years. This means that we cannot exploit within-country variability in our treatments to untangle a causal estimate of the effect of institutional conditions.

Several techniques rooted in the counterfactual tradition [94, 95] have been proposed to address the problem of covariate imbalance. While the specifics of the various methods vary, they are united in that their primary purpose is to take observational data and create covariate balance between treatment and control groups—that is, the goal of many counterfactual methods is to produce an analysis that mimics randomization of treatment assignment as occurs in experimental studies. Propensity score matching is one of the most common, if not the most common, method of addressing the covariate imbalance problem. Propensity score matching involves two steps. In the first step, the researcher implements a selection model (typically using binary logistic or binary probit regression) using treatment status as the dependent variable and variables that explain selection into the treatment or control group as predictors. Then, a probability of treatment (i.e., a propensity score) is calculated for each case, and treatment and control cases with similar propensity scores are matched [96, 97].

The propensity score method has several drawbacks. The most significant problem is model dependence. Typically, researchers use a rather ad hoc process to create the selection model, check said model against various diagnostics, and perhaps estimate additional models if diagnostics indicate that the selection model performs poorly. This process results in propensity scores that are sensitive to model specification. Recently, Hainmueller [98] proposed an alternative solution to the problem of covariate imbalance called entropy balancing. When given covariates, entropy balancing implements an algorithm that generates weights that balance sample moments (i.e., means, standard deviations) between treatment and control groups [96]. Thus, entropy balancing is inherently less model dependent than propensity score matching. The balancing weights are somewhat analogous to sampling weights more familiar to most social scientists. However, instead of correcting for the probability of selection, the balancing weights correct for covariate imbalance between the treatment and control groups on the variables entered in the algorithm.

For reasons we discuss further below, we cannot easily combine entropy balancing with many common panel regression estimators and thus cannot use fixed effects to remove within-subject variability. As an alternative, we first panel-demeaned all predictors, which has the effect of removing between-subjects' variability. After panel demeaning, we used the *ebalance* command in Stata 14 to execute entropy balancing [99]. The entropy balancing algorithm

Table 1 Descriptive statistics for predictor variables

	Mean	Std. dev.	Min	Max
Elected executive	0.436	0.496	0.000	1.000
Elected legislature	0.926	0.263	0.000	1.000
Political competition	0.917	0.276	0.000	1.000
Full	0.416	0.493	0.000	1.000
Military expenditures (% of GDP)	0.416	0.493	− 11.011	104.079
Exports (% of GDP)	2.836	10.661	− 43.095	67.710
Renewable energy consumption (% Total)	0.350	4.310	− 32.456	23.921
GDP per capita	− 0.078	0.191	− 1.131	1.219
GDP per capital squared	− 1.413	3.430	− 18.302	22.674
Urban population (% total)	5.206	4.580	− 4.949	23.899
All predictors group-demeaned				

successfully balanced all predictors on their first and second sample moments (that is, their means and standard deviations) and generated balancing weights to be used in regression models reported below.

Statistical models

As noted above, the output of entropy balancing is a weight that corrects for covariate imbalance. Many of the most common panel data estimators—such as the popular GLS estimator used by Stata's *xtreg* routine—require that weights are constant within panels. However, entropy balancing weights individual observations. In lieu of a more common panel data estimator, we opt for a multi-level generalized linear model (GLM) approach estimated with Stata/IC 14's *xtmixed* command using maximum likelihood with clustered standard errors. This estimator and general modeling strategy are rooted in the multi-level modeling tradition, also sometimes referred to as mixed models or hierarchical linear models [100, 101]. These models allow intercepts to vary randomly across countries, and in addition to the control variables identified above, we include year fixed effects. For the sake of parsimony, we do not report the results of the year fixed effects in our output tables.³ The countries included in our analysis are listed in the "Appendix" section.

Results and discussion

Table 2 provides results from the multi-level GLM specifications for each treatment variable. First, we consider the models for elected legislatures (model 1). This model suggests that countries with elected legislatures, as opposed to those with non-elected legislatures, do not systematically differ in terms of EIWB. Moving forward to our elected legislature treatment variable, we find that nations with elected legislatures, as opposed to those without, have improved EIWB but this effect is not statistically significant. In model 3 we estimated the effect of political competition. Here, competing political parties appear to increase EIWB but, as with prior models, this effect is not statistically significant. Model 4 tests the effect of a full democracy—defined as the combination of elected executives, elected legislatures, and competitive political parties—and again we observe a null effect.⁴ These models indicate that, once covariate imbalance is accounted for, democracy nor any of its specific subcomponents drive the energy intensity of well-being.

Overall, our results provide strong evidence that observed differences in the energy intensity of well-being across nations have little to do the extent of democratization in those nations. None of the facets

of democracy we consider in this paper—elected chief executive, elected legislature, or competitive parties—approach statistical significance and the effects of these variables are small in practical terms. Indeed, even "full" democratization, defined as the combination of an elected executive, elected legislature, and competitive political parties, appears to have no detectable effect on the energy efficiency of well-being. This finding is especially robust because we used entropy balancing to create statistical equivalence. This method is akin to treating institutional conditions as if they were randomly assigned across countries with respect to our predictor variables. Hence, this study provides relatively strong evidence that institutional conditions, in the form of different facets of democracy, have little to no impact on the energy intensity of well-being. Put another way, democracies do not appear to use their energy consumption anymore or less efficiently than non-democracies to improve well-being.

However, economic development, measured by GDP per capita, emerged as a key factor in EIWB. Indeed, GDP per capita and its quadratic transformation were the only consistent predictor across all four model specifications. In all models, growth in GDP per capita reduced EIWB, suggesting that growth in national wealth will facilitate more efficient use of energy to promote well-being.

However, this effect was non-linear in all models. Hence, it seems that income growth beyond a certain point might increase the EIWB. When estimating regression models with quadratic terms, it is important to ascertain the turning point in the relationship—that is, at what point does growth in GDP per capita increase EIWB, given that the quadratic term is statistically significant. Following Plassmann and Khanna [102], we performed the following calculation for each of our models:

$$\text{Turning point} = [(-\beta \log \text{GDP per capita} / (-2\beta \text{logged GDP per capita squared})]$$

Notably, the turning point for all models was at unusually high levels of GDP per capita growth. For instance, for the full democracy model, the turning point for was 9 units of logged GDP, beyond the actual range of the data. Thus, the relationship between economic development and EIWB is more or less linear across a typical range of the data. This finding is in contrast to [42], who report that economic growth might increase the ecological intensity of well-being, using ecological footprints and life expectancy in their ratio. One possible explanation for

Table 2 Mixed effect models for the energy efficiency of well-being

	Executive			Legislature			Political competition	Full democracy				
	b	se	p	b	se	p		b	se	p		
Elected executive	-7.183	316.627	0.982	-	-	-	-	-	-	-	-	-
Elected legislature	-	-	-	-18.432	332.570	0.956	-	-	-	-	-	-
Political competition	-	-	-	-	-	-	232.143	371.941	0.533	-	-	-
Full	-	-	-	-	-	-	-	-	-	50.561	196.812	0.797
Military expenditures (% of GDP)	89.077	77.109	0.248	130.058	144.170	0.367	101.574	68.497	0.138	38.716	50.477	0.443
Exports (% of GDP)	-0.970	5.412	0.858	3.725	9.752	0.703	-6.415	5.399	0.235	-3.989	4.843	0.410
Renewable energy consumption (% total)	4.511	25.885	0.862	59.118	71.617	0.409	-4.086	25.514	0.873	-12.108	12.201	0.321
GDP per capita (log)	-17,803.370	3009.469	0.000	-21,356.130	3799.184	0.000	-17,509.030	2707.017	0.000	-19,590.870	2415.219	0.000
GDP per capital squared (log)	998.197	178.945	0.000	1176.236	239.567	0.000	960.270	152.206	0.000	1121.018	138.468	0.000
Urban population (% total)	55.449	37.271	0.137	89.301	52.247	0.087	-12.065	54.849	0.826	31.470	23.430	0.179
Constant	29,872			29,403			29,911			30,530		
Std dev. (constant)	4196			4307			4312			3875		

All models include year fixed effects and entropy balancing weights. $n = 2150$ observations, 138 countries. All predictors are group-demeaned

these conflicting findings is that economic growth does not increase the energy intensity of well-being, but leads to other changes in production and consumption patterns that have a larger ecological impact. Disentangling the relationship between different indicators of ecological intensity is an important task for future research.

Across all model specifications, the percentage of energy consumption derived from renewable energy did not reach statistical significance and had a substantively small coefficient. The null findings for this variable imply that EIWB is not influenced by the source of energy. Thus, this null effect suggests that countries can increase their usage of renewable energy with no resulting change in the energy intensity of well-being. While renewable energy may not make nations more environmentally efficient, it also does not hinder well-being.

The null findings are somewhat surprising, given that studies have alternatively found that democracy improves or damages environmental performance at the national level. It is possible that our results differ because of methodological considerations—such as the choice of democracy indicator and use of causal inference techniques. Earlier, we noted that democracy might increase environmental degradation because it allows citizens to express their preference for more economic growth and consumption, while others suggest that democracy allows citizens to mobilize to protect the environment. Perhaps both countervailing dynamics are captured via national-level indicators of

democracy—future studies could attempt to capture citizen preferences for economic growth vs. environmental quality in varying national contexts.

Conclusion

Global energy consumption will increase drastically in the coming decades, creating immense environmental stress. Using energy resources more efficiently to improve human well-being while limiting environmental and public health impacts is a significant global development challenge. Hence, it is important to empirically document the factors that drive not only energy consumption and the efficient use of energy to promote human well-being. In this paper, we sought to extend the prior literature on the ecological efficiency of well-being by specifically examining the energy intensity of well-being in a sample of nations from 1990 to 2008 with a focus on institutional factors. We argued that, net of controls, the character of a nation's government may affect the efficiency by which said nation uses energy resources to promote well-being. In doing so, we used causal inference methods to isolate the effect of democracy on the energy intensity of well-being. We adopted a multi-faceted understanding of democracy informed by [26]. Initially, we expected that democracies would more effectively use energy consumption to improve well-being. However, our results indicated that full democracies fair no better on EIWB and there are no specific components of democracies (i.e., elected executives or legislatures) that impact EIWB. Hence, democratization

may translate into reduced environmental harm (net of other predictors) but it does not appear that democracies harness their energy consumption more efficiently in the promotion of the well-being of their populations. On the other hand, the null effect of democracy and its subcomponent suggest that democracy will not lead to less efficient energy use, either.

This study is not without limitations. While the entropy balancing method provides stronger causal evidence than more typical methods, we caution that our study does not fully determine if democracy causes (or does not cause) EIWB. More specifically, our models are robust against covariate imbalance on the predictors included in the entropy balancing algorithm but are not necessarily robust against omitted variable bias. Future studies could consider an alternative set of predictors to better understand the factors that explain cross-national variation in EIWB.

Endnotes

¹Rao and Baer [40] and Rao and Min [7] argue that “decent” standards of living should include considerations beyond mere subsistence needs such as access to communication technology and refrigeration as well as education and health services, implying the need for infrastructure build-out in developing nations. Unpacking these considerations are beyond this paper, but the authors encourage interested readers to consult their analyses.

²GNI or GDP per capita can be measured in many ways, and popular data sources such as that hosted by the World Bank provide several different measures of economic development. In unreported analyses, we accessed and correlated several measures of GNI and GDP per capita and found that they were all strongly related ($r > .85$). This suggests that our results are not sensitive to the choice of a particular indicator of economic development.

³Some studies (e.g., [103]) have detected significant temporal variability in the relationship between predictors like economic development and the ecological intensity of well-being. We estimated a series of unreported models wherein we removed the year fixed effects and inserted an interaction term between time (in our case, a linear year term) and our treatment variables. These models suggested that the largely null effects reported here are stable across time.

⁴The null effects could exist if our democracy variables were highly collinear with other predictors. We assessed multicollinearity with variance inflation factors (VIFS), and with the exception of GDP per capita and its quadratic term, the VIFs were all below two, indicating that multicollinearity does not plague our models.

Appendix

Table 3 Countries included in analysis

Albania	Djibouti	South Korea	Russian Federation
Algeria	Dominican Rep.	Kuwait	Saudi Arabia
Angola	Ecuador	Kyrgyz Rep.	Senegal
Argentina	Egypt, Arab Rep.	Latvia	Seychelles
Armenia	El Salvador	Lebanon	Singapore
Australia	Equatorial Guinea	Libya	Slovak Republic
Austria	Eritrea	Lithuania	Slovenia
Azerbaijan	Estonia	Luxembourg	South Africa
Bahrain	Fiji	Macedonia	Spain
Bangladesh	Finland	Malaysia	Sri Lanka
Belarus	France	Malta	Sudan
Belgium	Gabon	Mauritius	Swaziland
Belize	Gambia, The	Mexico	Sweden
Benin	Georgia	Moldova	Switzerland
Bolivia	Germany	Mongolia	Syria
Bosnia and Herzegovina	Ghana	Morocco	Tajikistan
Botswana	Greece	Mozambique	Tanzania
Brazil	Guatemala	Myanmar	Thailand
Brunei Darussalam	Guinea-Bissau	Namibia	Togo
Bulgaria	Guyana	Nepal	Trinidad and Tobago
Cabo Verde	Haiti	Netherlands	Tunisia
Cambodia	Honduras	New Zealand	Turkey
Cameroon	Hungary	Nicaragua	Turkmenistan
Canada	India	Niger	Ukraine
Chile	Indonesia	Nigeria	United Arab Emirates
China	Iran, Islamic Re	Norway	United Kingdom
Colombia	Iraq	Oman	United States
Congo, Rep.	Ireland	Pakistan	Uruguay
Costa Rica	Israel	Panama	Uzbekistan
Cote d'Ivoire	Italy	Paraguay	Venezuela
Croatia	Jamaica	Peru	Vietnam
Cuba	Japan	Philippines	Yemen
Cyprus	Jordan	Poland	Zambia
Czech Republic	Kazakhstan	Portugal	Zimbabwe
Denmark	Kenya	Qatar	

Abbreviations

EIWB: Energy intensity of well-being

Acknowledgements

The author thank the editorial staff and anonymous reviewers for their helpful commentary.

Funding

The author received no funding to conduct this research.

Availability of data and materials

All data used in this analysis is freely available via the links included in the text and references.

Authors' contributions

AM wrote the manuscript, gathered the data, and implemented the analysis.

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Ethics approval and consent to participate

This study uses public, aggregated secondary data and is exempt from standard human subjects' ethics approval.

Consent for publication

The author consents to publication.

Competing interests

The author declares that he has no competing interests.

Publisher's Note

Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Received: 11 July 2017 Accepted: 17 October 2017

Published online: 01 December 2017

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