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Perceptions and Experiences: A Two-dimension Framework for Energy Insecurity and its Effects on Self-rated Health in a Rural Setting

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Perceptions and Experiences: A Two-dimension Framework for Energy Insecurity and its Effects on Self-rated Health in a Rural Setting

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Abstract

A burgeoning body of scholarship links energy insecurity to health outcomes, including self-rated health. Here, we advance a two-dimensional framework for energy insecurity that differentiates between ideational and experiential elements. Using data from rural Colorado, USA—a region that has historically produced ample energy via a now-declining coal industry—we evaluate how the ideational and experiential dimensions of energy insecurity influence self-rated health in the context of a dwindling coal industry. Results imply that ideational energy insecurity has a unique and powerful effect on self-rated health, while the effect of priming respondents about coal's regional decline is conditioned by ideational energy insecurity.

Keywords: energy insecurity, self-rated health, rural health

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Perceptions et expériences : un cadre bidimensionnel pour l'insécurité énergétique et ses effets sur l'autoévaluation de la santé en milieu rural

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Résumé

Un nombre croissant d'études établissent un lien entre l'insécurité énergétique et les résultats en matière de santé, incluant l'autoévaluation de la santé. Ici, nous avançons un cadre bidimensionnel pour l'insécurité énergétique qui différencie les éléments idéationnels et expérientiels. À l'aide de données provenant du Colorado rural, aux États-Unis, une région qui a historiquement produit beaucoup d'énergie grâce à une industrie du charbon en déclin, nous évaluons comment les dimensions idéationnelles et expérientielles de l'insécurité énergétique influencent l’autoévaluation de la santé dans le contexte d'une industrie du charbon en déclin. Les résultats impliquent que l'insécurité énergétique idéationnelle a un effet unique et puissant sur l’autoévaluation de la santé, tandis que l'effet d'informer les répondants sur le déclin régional du charbon est conditionné par l'insécurité énergétique idéationnelle.

Mots clés : Insécurité énergétique, autoévaluation de la santé, santé rurale

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1.0 Introduction

The concept of energy insecurity has received increasing attention in the social and health sciences. Although the theoretical specifics vary, a household is thought to be energy secure when it has access to reliable, affordable, and sustainable energy services (Ang et al. 2015; Chester, 2010; Sovacool, 2016; Hernández, 2016). Energy insecurity, therefore, refers to situations where an individual lacks key energy services, often because energy services are unreliable, too expensive, or otherwise inaccessible.

Energy security is essential for human flourishing (Sweidan & Alwaked, 2016; Ouedraogo, 2013; O'Neill et al., 2018). In high-income states, energy consumption often well exceeds levels necessary to optimize human well-being, commonly measured by human development indexes or population health outcomes (Goldemberg et al. 1985; Rao & Min, 2018, Steinberger & Roberts 2010). However, energy insecurity persists for some households and is regionally clustered. Lower-income households face greater energy burdens, with a larger proportion of their household income allocated to energy than middle and higher-income homes (Drehobl & Ross, 2016).

Considering the U.S., Hernandez (2016) provides a holistic account of energy security, denoting three core domains: economic, physical, and behavioral. Economic energy security reflects an individuals' ability to afford sufficient energy services (e.g., cooling, heating, power for essential household items). Physical energy security is the condition of the built environment surrounding households, such as weatherization and the quality of energy infrastructure. Lastly, behavioral energy security refers to the capacity for an individual to reduce the intensity of their energy insecurity.

Similarly, we propose that energy insecurity can be partitioned into two distinct constructs. First, *experiential energy insecurity* captures specific household or personal experiences of energy insecurity. These include household and individual level experiences like inadequate thermal comfort, having a utility company threaten to or shut-off service, or otherwise having insufficient energy services to fulfill daily tasks (e.g., Cook et al. 2008; Hernandez & Siegel 2016).

Several studies have connected issues of experiential energy insecurity to indicators of individual well-being, such as self-rated health (Mayer & Smith 2019; Hernández & Siegel, 2019; Lacroix & Jusot, 2014; Lacroix & Chaton, 2015), sleep problems (Hernandez & Siegel, 2019), asthma (Hernandez & Siegel, 2019), depression (Hernandez & Siegel, 2019), increased youth hospitalizations (Cook et al., 2008), and excess mortality during cold months (Healy, 2003). Furthermore, children and the elderly may be especially vulnerable to the problems caused by energy insecurity, particularly as climate change intensifies severe weather patterns (Healy & Clinch, 2002; Anderson et al., 2018). At the county scale, energy burden is associated with poor health outcomes (Reames et al., 2021).

Second, a much smaller body of literature evaluates what we call *ideational energy insecurity*. These studies consider individual *perceptions* of the security of their national energy system or their household's access to key energy services. At the country-level, energy imports and human development are associated with diminished levels of ideational energy insecurity (Demski et al., 2018). Ideational energy security is also linked to support for renewable energy policies in western European states (Marquart-Pyatt et al., 2019).

The relationship between ideational energy insecurity and individual well-being has received comparatively less attention. The key notion here is that worry, stress or concern about energy supplies, energy services, and related concepts could increase stress, worry, or dread and induce a loss of well-being. That is, ideational energy insecurity acts as a specific form of stress and increased worries, factors commonly associated with decreases to an individual's well-being (Diener & Ryan, 2009). Using the cross-national data from the 2016 European Social Survey, Mayer and Smith (2019) find that individuals who were worried about their energy security had lower self-rated health (in particular, they were less likely to state that they had "very good" health).

Here, we explore the distinct roles of experiential and ideational energy insecurity shaping individual well-being. As of current, the effects of ideational energy insecurity on an individual's health remains less documented, particularly outside of the European context. Currently, little is known about the relationship between the experiential and ideational forms of energy insecurity. This research addresses this gap. Furthermore, we investigate how exposure to information about declining localized coal production affects individual perceptions of well-being, both directly and indirectly, via an interactive relationship with ideational energy security.

Using novel survey data from a rural region in western Colorado, USA, we compare the effects of household experiences with energy insecurity, individual perceptions of the security of the energy system, and exposure to information about decreased coal production on self-rated health. In the next section, we describe the data and methods used to evaluate these relationships.

2.0 Methods

2.1. Data

A large volume of research on energy security has been conducted in metropolitan areas in the eastern U.S. (e.g., Hernandez & Siegel, 2019; Hernandez, 2016), with more rural and Western regions receiving comparatively less attention. We situate our work in western Colorado, where the current study is part of a broader research project to examine community and well-being impacts of the changing energy system in this area. Western Colorado is historically a rural, rugged region that has relied upon a mix of extractive industries, tourism, recreation, and agriculture as its economic bedrock.

In the fall of 2018, we collected novel online survey data via Qualtrics, a well-established provider of online panels. Online panels have been increasingly used in academic research as they provide an efficient means to collect data, particularly for populations that are understudied and more difficult to reach. Online-sourced survey data tends to align with survey data from more conventional modes, such as mail or random digit dial (Johnson, 2016; Roulin, 2015). Online panels are especially appropriate for preliminary or exploratory research into new topics, although we remind readers of the standard caveats of non-probability sampling techniques (Cornesse et al., 2020).

Qualtrics collects data using an online dashboard system or occasionally via direct email recruitment. Respondents are compensated through a variety of means, ranging from cash gift cards to rewards points. Qualtrics representatives and our research team worked together to scrub the data for cases of satisficing (i.e., respondents who provided the same answer over and over again), skipping many questions, failing the attention check, or living outside the study region**.**

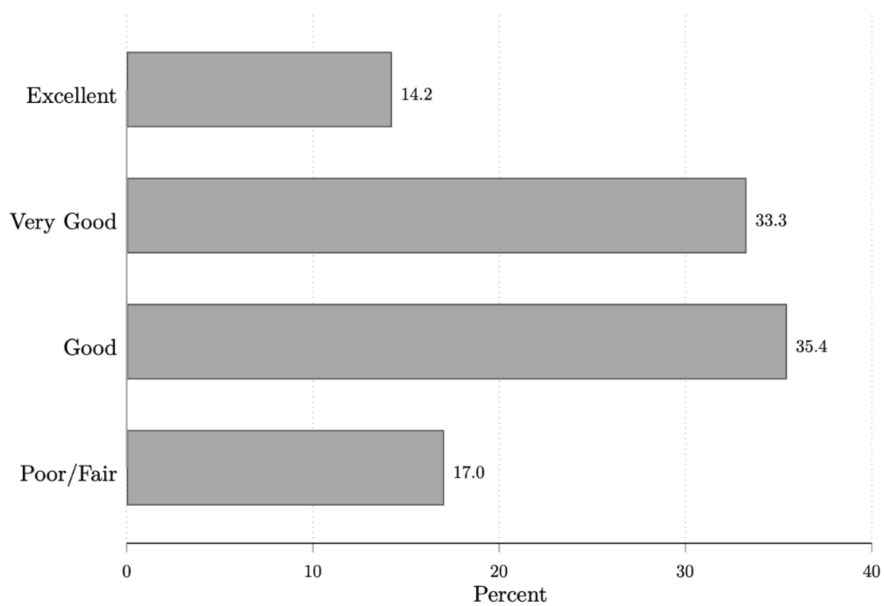
We sampled the following 14 counties: Moffat, Routt, Rio Blanco, Garfield, Mesa, Delta, Gunnison, Montrose, Ouray, San Miguel, San Juan, Delores, La Plata, and Montezuma. Although these counties are largely rural, they possess a great deal of economic diversity. Moffat and Rio Blanco counties have relied upon coal mining and coal-fired powerplants as a primary source of employment and tax revenue, while counties like Gunnison and Routt boast ample tourism economies. Western Colorado has also benefitted from natural gas production, which is primarily concentrated in Garfield county. The overall sample size for this research is n=366.

2.2 Outcome Measure: Self Rated Health

Our outcome measure is self-rated health (SRH). SRH has been widely employed across the health and social sciences, providing a non-intrusive, validated indicator of an individual's overall health status. For instance, SRH is associated with more objective measures of health status like obesity and mortality (Schnittker & Bacak, 2014; Lundberg & Manderbacka, 1996; ,Benyamini, 2011; Cislaghi & Cislaghi, 2019). Further, SRH is also associated with changes in actual health status—for example, Okosun et al. (2011) find that individuals reported increased SRH after a significant weight loss.

In our application, respondents were asked: "In general, would you say that your health is excellent, very good, good, fair, or poor?" Given that few respondents stated "fair" or "poor", we combined these categories to avoid issues of data sparsity. The response distribution of SRH is displayed in Figure 1.

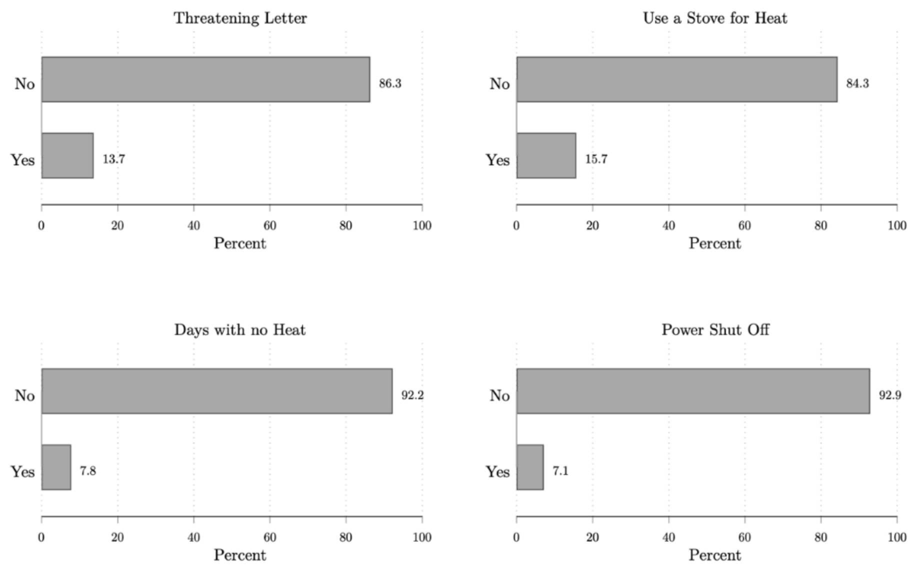
Figure 1. Distribution of reported SRH.



2.3 Predictor Variables

2.3.1. Energy Insecurity: Experiential and Ideational. For this research, we explore the distinction between the experiential and ideational domains of energy security. To capture *experiential energy insecurity*, we replicated items used in Cook et al. (2008). Respondents were asked a series of questions, exploring if they had experienced any of the following during the previous year: (i) received a letter from an energy utility threatening to shut-off their energy, (ii) used a stove to heat their house, (iii) had their electricity shut-off (iv) had days that their household did not have adequate heat. Figure 2 provides the distribution of these items. Each of the individual energy insecurity items was experienced by between 7% and 15% of respondents, with receiving a threatening letter from a utility company being the most common experience. Some 24% of respondents indicated that they experienced at least one form of energy insecurity.

Figure 2. Distribution of energy insecurity experiences.



For *ideational energy security*, we used a set of questions from Wave 8 of the European Social Survey (2016) to capture how individuals assess the security of their energy system. Each variable uses five-item response categories (not at all worried, not very worried, somewhat worried, very worried, and extremely worried). Respondents were asked the extent to which they were worried about: (i) power cuts in their area, (ii) energy becoming too expensive, (iii) natural disasters reducing energy supply, (iv) supply shocks, (v) technical failures, and (vi) terrorist attacks on the energy systems (see Figure 3). We conducted a factor analysis to evaluate the dimensionality of these items. The first step was estimating a polychoric correlation matrix—polychoric correlations are recommended for categorical data (Holgado–Tello et al., 2010). Then, we used the iterated principal factors method to extract factors. As shown in Table 1, the factor analysis strongly indicated that a single latent factor underlies these five items. Accordingly, we then estimated a factor score from these items to create the ideational energy insecurity scale, which we utilize as a predictor in our subsequent regression models.

Figure 3. Distribution of ideational energy security items (%).

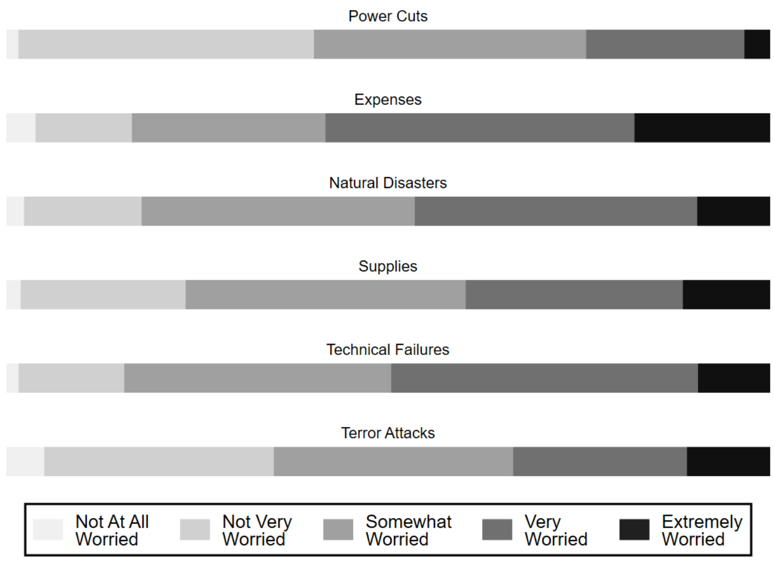


Table 1. *Iterated Principal Factor Analysis for Ideational Energy Security*

	Factor 1	**Factor 2**
Power Cuts	0.67	-0.13
Expenses	0.56	-0.22
Natural Disasters	0.77	0.25
Supply	0.83	-0.24
Technical Failures	0.80	0.11
Terror Attacks	0.44	0.29

Eigenvalue=2.87, KMO=0.85

2.3.2. Coal Decline Informational Treatment. Historically, Western Colorado has experienced a series of booms and busts for different types of fossil fuel extraction—such as the short shale oil boom and busts that occurred a few times in the 20th century (Gulliford, 1986). The energy industry in the region has undergone significant transitions in recent years. Among these changes, the coal sector has steadily contracted, and the few remaining mines and powerplants are likely to close within the next several years, a reflection of a broader trend of coal mine closures and transitions in the energy system (Houser et al., 2017; Carley et al., 2018; Graff et al., 2018). Coal production is also often seen as a form of social identity in rural communities (Bell & York, 2010), and the economic impact of coal on the region is often greatly overestimated (Blaacker et al., 2012).

Our survey included an experimental informational treatment, aimed to prompt respondents' attention to the decline of coal production. Half of the respondents were randomly assigned the informational treatment, "As you may know, the coal industry in western Colorado is currently experiencing hardship and the coal mines may close in the future."

Those who were randomly assigned to the control group did not receive this statement before being prompted to answer questions about ideational energy insecurity. As such, we analyze the effects of the experimental treatment directly, and indirectly, via an interaction product term with ideational energy insecurity.

2.4 Control Variables

SRH is linked to socio-economic indicators (Blakely et al.; Ahs & Westerling, 2005). To mitigate potential confounding effects of these variables, we include controls for the respondent's gender, age, income, educational attainment, and racial/ethnic identity. See Table 2 for descriptive statistics and item coding for all variables.

Table 2. *Descriptive Statistics and Item Coding*

	Item Coding	**Mean**	**SD**
Outcome			
SRH	*1=poor/fair, 2=good, 3= very good, 4=excellent*	2.45	0.94
Focal Predictors			
Experiential Energy Insecurity			
Threatening Letter	*1=did not receive letter, 2= received letter*	1.14	0.34
Using a stove for heat	*1=used stove for heat, 2=used stove for heat*	1.16	0.27
Days with no heat	*1=adequate heat,2=days with no heat*	1.07	0.26
Power shut-off	*1=no shut- off, 2= shut-off*	1.07	0.25
Ideational Energy Insecurity			
Energy System Worries	*Factor Score: higher scores are more worry*	3.97	0.86
Informational Experimental Treatment			
Coal Decline	*0=did not receive coal decline treatment, 1= receive coal decline treatment*	0.53	0.50
Controls			
Female	*0=does not identify as female, 1= identifies as female*	0.50	0.50
College	*0=less than college, 1= college degree or higher*	0.41	0.49
Age	*Age in years*	42.01	17.82
Income	*0=less than $25,000, 1=$25,000-$49,999, 2=$49,999-99,999, 3= $100,000-$149,999, 4=$150,000 or more*	1.22	1.10
White	*0=does not identify as white, 1= identifies as white*	0.84	0.37

3.0 Modelling Strategy

We analyzed our data in two steps. Given the exploratory nature of this research, we first calculated the polychoric correlation matrix between our two constructs of energy insecurity and SRH. As the indicator for SRH is on the ordinal scale, we used an ordinal logistic regression approach to estimate the effect of our predictors of SRH. Using entropy balancing methods (Hainmueller, 2012; Watson & Elliot, 2016), we calculated weights to correct for differences with the state-level distributions of sex, age, income, and college education. These weights were applied to all the ordinal logistic regression models. Table 3 provides further information about this procedure.

Table 3. *Comparison of Sample and Population Data before Entropy Balancing*

	Sample Data (2019)	**ACS 5 Year Estimates for Colorado (2015-2019)**	**ACS Estimates for US Population (2019)**
Female	71.5%	49.7 %	50.8%
College Degree	42.9%	40.9 %	33.1%
White	91.8%	84 %	76.3%

We estimated five models using a nested regression approach. The first model includes only the variables for experiential energy security, the second adds the factor score for ideational energy insecurity, the third model includes the socio-demographic controls, the fourth model includes the coal decline informational treatment, and the fifth and final model adds in an interaction between the coal decline treatment and ideational energy insecurity. We used AIC and BIC and the Lacy R^2_0 (Lacy, 2006) to determine improvements to model fit after the inclusion of the new variables.

The substantive effect of regression estimates on the logistic scale are notoriously difficult to interpret. Further, analyses focused solely on statistical significance can lead to false conclusions and misinterpretation of results (Amrhein et al., 2019). Accordingly, we engage in post-estimation analyses, using predicted probabilities to identify the substantive effects our these results (Long & Freese, 2006, Mood, 2010) Predicted probabilities were calculated using the -margins- approach at different levels of key predictors, predicting the highest value of SRH (“excellent”), holding control variables at their observed values.

For the direct effects (Model 4), we calculated average marginal effects (AMEs) for the four items that capture experiential energy insecurity (Williams, 2012). As these indicators are binary, the AMEs can be interpreted as the difference between the predicted probability of those who have experienced this form of energy insecurity, and those who have not. Next, we calculated the predicted probability for the ideational energy security scale, predicted at the values range [-2SD, -1SD, mean, +1SD, +2SD].

Lastly, we calculated predicted probabilities for the product-term interaction (Model 5), using the same value range of ideational energy scale [-2SD, -1SD, mean, +1SD,

+2SD] interacted by a dummy indicator for whether the respondent received the informational treatment or the control. Predicted probabilities are necessary to determine the nature of interactive effects on a logistic scale (Brambor et al., 2006), as the coefficients of the product term do not provide sufficient information on the significance, magnitude, or direction of this interaction (Mize, 2019).

4.0 Results

4.1 Correlational Analysis

Table 4 provides polychoric correlations between SRH and experiential/ideational energy insecurity. Most of the correlations between SRH and the experiential energy insecurity items are small, except for receiving a letter ($\rho = -0.23$). Furthermore, SRH is negatively correlated with the ideational energy insecurity scale ($\rho = -0.16$). We also found relatively modest yet positive associations between ideational energy insecurity and actual experiences of energy insecurity—that is, those who have experienced electricity shut-off ($\rho = 0.23$) or lacking adequate heating ($\rho = 0.27$) have moderately more ideational energy, but we found no association between receiving a letter and ideational energy insecurity.

Table 4. *Polychoric Correlations Between SRH, and Experienced and Ideational Energy Insecurity*

	SRH	**Letter**	**Stove**	**No Heat**	**Shut-off**
Letter	-0.23				
Stove	-0.17	0.48			
No Heat	-0.10	0.64	0.73		
Shut-off	-0.11	0.77	0.71	0.93	
Ideational Energy Insecurity	-0.16	0.00	0.22	0.27	0.23

4.2 Regression Analyses

Table 5 displays estimates for the ordinal logistic regression models that predict SRH. Model 1 includes only the experiential energy insecurity items, of which receiving a letter is the sole statistically significant predictor *(b=-0.80, p<0.05)*, implying that people who have received a threatening letter from an energy or utility company within the past year have lower SRH. Next, Model 2 includes the ideational energy insecurity scale, which is positive and statistically significant *(b=-0.29, p<0.05)*. That is, an individual's SRH declines as their perceived insecurity of the energy system increases. Model 3 adds in socio-demographic variables. Importantly, ideational energy insecurity and receiving a threatening letter retain their statistical significance even when controlling for socio-demographics.

Table 5. *Ordinal Logistic Regression Models for SRH*

	Model 1 *Experiential Energy Insecurity*	**Model 2** *Ideational Energy Insecurity*	**Model 3** *Socio-demographics*	**Model 4** *Full Direct Effects*	**Model 5** *Interaction*
Experiential Energy Insecurity					
Received Letter	-0.80*	-0.85*	-0.87**	-0.76*	-0.78*
	(0.33)	(0.33)	(0.33)	(0.34)	(0.34)
Stove for Heating	-0.40	-0.34	-0.14	-0.20	-0.25
	(0.28)	(0.28)	(0.29)	(0.29)	(0.29)
Days with no Heat	-0.07	-0.04	0.25	0.09	0.20
	(0.52)	(0.52)	(0.54)	(0.54)	(0.54)
Electricity Shut-off	0.26	0.36	0.27	0.32	0.32
	(0.54)	(0.54)	(0.56)	(0.56)	(0.56)
Ideational Energy Insecurity					
Energy System Worries		-0.29*	-0.28*	-0.32**	-0.62**
		(0.11)	(0.12)	(0.12)	(0.17)
Controls					
Female			0.41*	0.41*	0.48*
			(0.20)	(0.20)	(0.20)
College Education			0.67**	0.70**	0.68**
			(0.22)	(0.22)	(0.22)
Age			-0.02**	-0.02**	-0.02**
			(0.01)	(0.01)	(0.01)
Income			0.48**	0.45**	0.44**
			(0.10)	(0.10)	(0.10)

Table 5 continued

White			0.88**	0.88**	0.78**
			(0.28)	(0.28)	(0.29)
Informational Experimental Treatment					
Coal Decline				-0.45*	-2.79**
				(0.20)	(0.97)
Treatment*					0.59*
Energy System Worries					(0.24)
AIC	964.63	959.90	910.82	908.01	903.84
BIC	991.95	991.12	961.55	962.65	962.38
Lacy R_2^O	0.02	0.03	0.12	0.13	0.14
N	366	366	366	366	366

Note: Coefficients are log-odds, with standard errors presented in parentheses; * $p < 0.05$, ** $p < 0.01$; data derived from a survey of Western Colorado residents.

Model 4 presents fully elaborated, direct effects regression estimates. Having received a letter threatening energy shut-off is the only item of experiential energy security that has a significant effect, which is negatively associated with SRH *(b=-0.76, p<0.05)*. While ideational energy security also has a negative, significant effect *(b=-0.32, p<0.05)*. Furthermore, the direct effect of the coal decline treatment on SRH is also statistically significant and negative *(b=-0.42, p<0.05)*. That is, receiving information that the coal industry is struggling reduces SRH directly, not via other variables like ideational energy insecurity.

Lastly, we included an interaction product term between the informational treatment and ideational energy insecurity in Model 5. Here we find a statistically significant interaction (b=0.59, p<0.05). The AIC, BIC, and Lacy R20 are all improved in Models 4 and 5, implying improved model fit. Consistent with the broad literature on health inequalities, Models 3-5 also imply that whites and persons with higher socio-economic status (i.e., more education and income) have comparatively better SRH.

4.3 Probabilities

For the final step in our analysis, we calculated predicted probabilities for "excellent" SRH (i.e., the highest category). These probabilities were calculated at the mean of ideational energy insecurity and plus or minus 1 and 2 standard deviations (presented in Figure 4). The probabilities imply that, as ideational energy insecurity increases, the probably of a respondent reporting that they are in "excellent" health declines. This probability of having excellent SRH drops from 0.21 when ideational energy insecurity is very low to 0.09 when ideational energy insecurity is very high (i.e., two standard deviations above the mean). Thus, in addition to having a statistically significant effect, ideational energy security appears to be quite substantive in practical terms.

Figure 4. Predicted probabilities of "Excellent" SRH across scores of ideational energy security with 95% confidence intervals. Note: Probabilities were calculated by holding all other variables at their observed values.

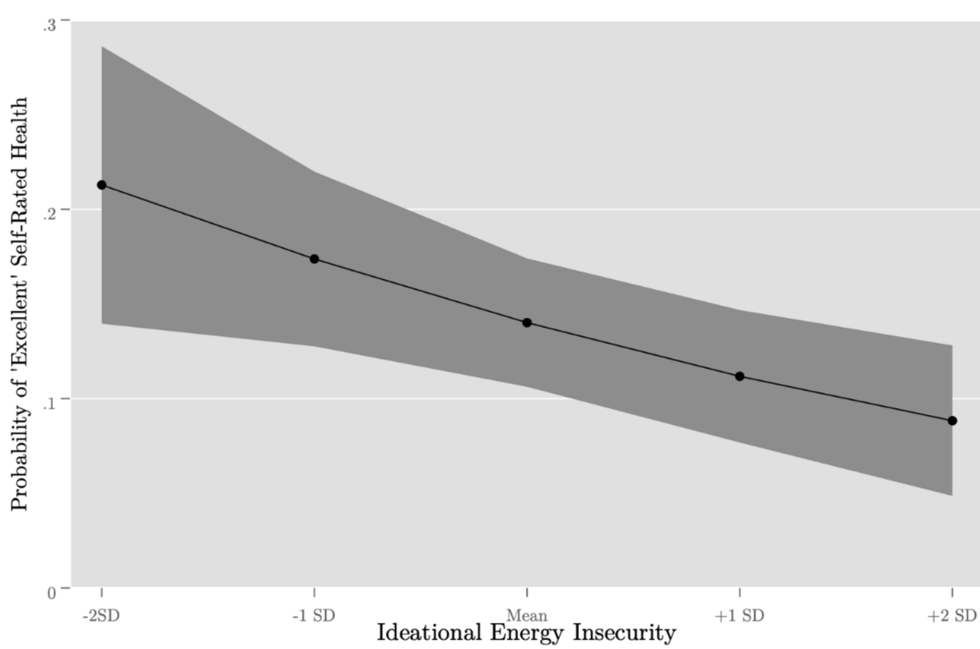
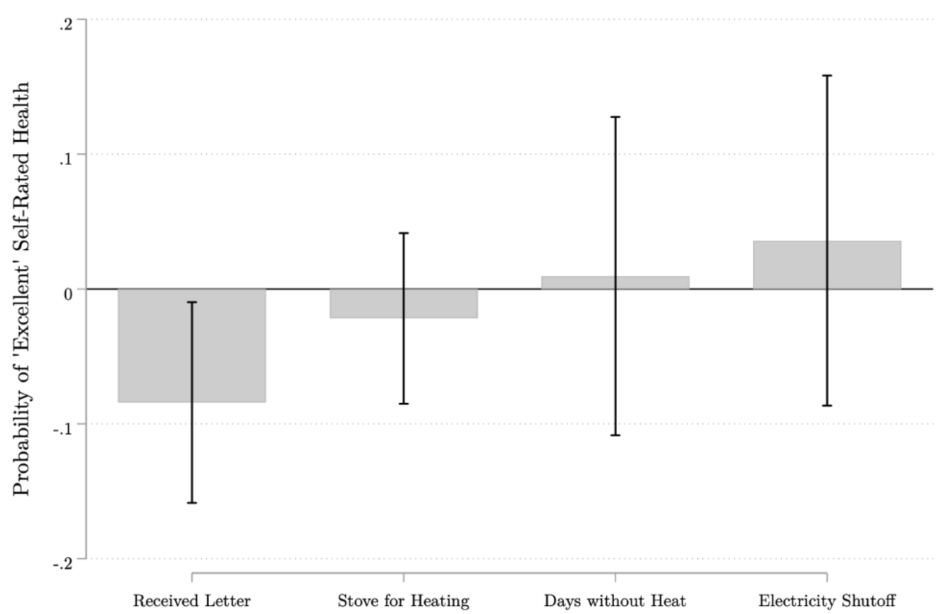


Figure 5 provides average marginal effects for the experiential energy insecurity items on the probability of "excellent" SRH. Receiving a threatening letter has a negative effect on SRH (AME=-0.08), while the AMEs for the other three variables are comparatively small. That is, people that received a letter are 8% less likely to have excellent SRH than those who did not receive a letter.

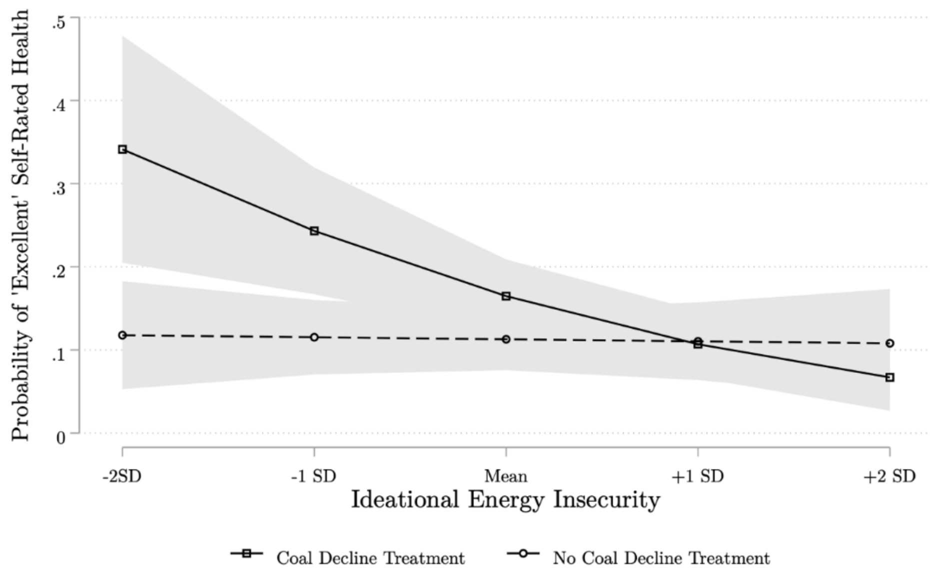
Lastly, Figure 6 displays the interaction product term between the coal decline treatment and ideational energy insecurity on the probability of "excellent" SRH. The probabilities reveal some complexity behind the interaction. At low levels of ideational energy insecurity, there is a significant gap between those who received the information treatment and those who had not. But counterintuitively, respondents who were told that the coal industry was declining had a higher probability of reporting "excellent" health when ideational energy insecurity was low. Yet, as energy insecurity increases, the probability of "excellent" SRH declines sharply, where there are minimal differences between those who did (and did not) receive the treatment at higher levels of energy insecurity (e.g., the probabilities hover around 0.10 for both groups). Further, probabilities for the treatment and control groups converge, such that the groups are very similar at high levels of ideational energy insecurity.

Figure 5. Average marginal effect of experiential energy insecurity on "excellent" SRH of "excellent" SRH across scores of experiential energy insecurity items, with 95% confidence intervals.



Note: Probabilities were calculated by holding all other variables at their observed values.

Figure 6. Predicted probabilities of "Excellent" SRH across scores of coal treatment * ideational energy security interaction product term, with 95% confidence intervals.



Note: Probabilities were calculated by holding all other variables at their observed values.

4.4 Robustness Check

As a final step in our analysis, we utilize the Konfound method (see Table 6) to assess the robustness of our findings using the estimates from Model 5 (Frank et al., 2013; Xu et al., 2019). Konfound estimates the percentage of cases that would need to be replaced with a case of null effect for a statistically significant finding to render that finding non-significant, and vice versa. For receiving a letter, 14% of the sample, or 51 cases, would have to be replaced with a case with a null effect to change the coefficient to statistically insignificant at alpha= 0.05. On the other hand, ideational energy security (our variable *Energy System Worries*) would have to have 26.4%, or 97 cases, be replaced with a case of null effect to render the result statistically insignificant.

Table 6. *Results of Konfound Analysis*

	%	**Number of Cases**
Letter	14.0%	51
Stove	65.4%	---
No Heat	91.9%	---
Shut-off	70.7%	---
Energy System Worries	26.4%	97

5.0 Discussion

Recent scholarship has noted an association between energy insecurity and indicators of health and well-being. While this literature has largely focused on experiences with energy insecurity, we suggest that energy insecurity has at least two broad dimensions—an *experiential* dimension that is manifested in various household or personal experiences with energy insecurity (e.g., lack of adequate energy services, thermal discomfort, energy intermittency) and an *ideational* dimension that refers to perceptions of energy insecurity.

We found that household experiences with energy insecurity did not reduce SRH, with the lone exception of receiving a threatening letter. The null findings are in contrast with recent literature (e.g., Hernandez & Siegel, 2016). Much of the literature on energy insecurity has focused on large, metropolitan regions, sometimes using targeted sampling of low socio-economic status neighborhoods (e.g., Hernandez and Siegel 2019; Memmott et al., 2021). In contrast, we used data from western Colorado, a region that is a mix of rural areas and small cities. Energy insecurity is certainly present in a setting such as this, but these findings suggest that rural and small city households in the Mountain West may experience energy insecurity in different ways than households in large metropolitan regions. For instance, rural residents may be more likely to have alternative, temporary sources of energy services—such as solar energy systems, wood burning stoves, or generators—that may represent an adaptation to an insecure energy system (e.g., Dizard, 2021). Accordingly, these findings suggest that there is a need to evaluate the nature of energy insecurity in rural settings, as it may differentially affect health outcomes.

Ideations about the security of the energy system have seldom been studied in the literature and are rarely linked to indicators of well-being (Mayer and Smith 2019 is one notable exception). Our research provides further support for an association between the two. Yet the origins of these perceptions are not well known—that is, how do individuals form their perceptions about the broader energy system? Why do perceptions affect SRH? These questions should be evaluated by future scholars working in the areas of energy insecurity and energy justice. Further, given the negative effect on health outcomes, subsequent research should work to identify mechanisms that reduce worries about the energy system. Is worry and stress about the energy system more common in places experiencing energy transition, or not?

Lastly, we found that cueing respondents about the changing energy system (i.e., the decline of coal) had complex effects on SRH. For individuals with little to no ideational energy insecurity, the coal decline treatment appeared to *improve* SRH—it is possible that these persons might associate coal with poor public health outcomes, or generally not have a favorable view of the industry, and hence being told that the industry is collapsing did not reduce their SRH. Yet, as ideational energy insecurity increased, the effect of the coal mine treatment became increasingly negative. People who are not worried about energy security may have more secure energy sources, and more stable living conditions. Given their lower worries about energy security, it is possible that these people may tend to be more in favor of emerging energy sources, such as renewable energies, and therefore, the decline of a traditional energy source, such as coal, may be less of a driver of concern. Our results suggest that, in fact, prompting these people about the decline of coal provides a positive SRH-benefit. These findings imply that changes in the energy system likely interact with perceptions of energy insecurity in complicated ways to reduce or improve subjective well-being. Further research in this area is needed to clarify these relationships.

The experiential and ideational energy insecurity organizing framework we employ here may be useful for future studies. Note that we explore worries about the energy system writ large—not perceptions of energy insecurity at the individual or household scale. Addressing this gap is important for future research because it could illuminate the link between experiences of energy insecurity and well-being. Perhaps individuals or households who have struggled with energy bills or had their services terminated will experience a marked degree of worry that will reduce their well-being for a substantial period after the energy insecurity event. The link between energy insecurity—be it experiential or ideational—and well-being should be unpacked further in future analyses.

References

Ahs, A., & Westerling, R. (2005). SRH in relation to employment status during periods of high and of low levels of unemployment. *European Journal of Public Health, 16*(3), 294–304. https://doi.org/10.1093/eurpub/cki165

Amrhein, V., Greenland, S., & McShane, B. (2019). *Scientists rise up against statistical significance.* Nature Publishing Group. https://www.nature.com/articles/d41586-019-00857-9

Anderson, G. B., Oleson, K. W., Jones, B., & Peng, R. D. (2018). Projected trends in high-mortality heatwaves under different scenarios of climate, population, and adaptation in 82 US communities. *Climatic Change*, *146*(3), 455–470. https://dx.doi.org/10.1007%2Fs10584-016-1779-x

Ang, B. W., Choong, W. L., & Ng, T. S. (2015). Energy security: Definitions, dimensions and indexes. *Renewable and Sustainable Energy Reviews*, *42*, 1077–1093. https://doi.org/10.1016/j.rser.2014.10.064

Bell, S. E., & York, R. (2010). Community economic identity: The coal industry and ideology construction in West Virginia. *Rural Sociology*, *75*(1), 111–143. https://doi.org/10.1111/j.1549-0831.2009.00004.x

Benyamini, Y. (2011). Why does SRH predict mortality? An update on current knowledge and a research agenda for psychologists. *Psychology of Health*, *26*(11), 1407–1413. https://doi.org/10.1080/08870446.2011.621703

Blaacker, D., Woods, J., & Oliver, C. (2012). How big is big coal? Public perceptions of the coal industry's economic impact in West Virginia. *Organization & Environment*, *25*(4), 385–401. https://doi.org/10.1177%2F1086026612464766

Blakely, T. A., Lochner, K., & Kawachi, I. (2002). Metropolitan area income inequality and SRH—A multi-level study. *Social Science & Medicine*, *54*(1), 65–77. https://doi.org/10.1016/s0277-9536(01)00007-7

Brambor, T., Clark, W. R., & Golder, M. (2006). Understanding interaction models: Improving empirical analyses. *Political Analysis*, *14*(1), 63–82. https://doi.org/10.1093/pan/mpi014

Carley, S., Evans, T. P., & Konisky, D. M. (2018). Adaptation, culture, and the energy transition in American coal country. *Energy Research & Social Science*, *37*, 133–139. https://doi.org/10.1016/j.erss.2017.10.007

Chester, L. (2010). Conceptualising energy security and making explicit its polysemic nature. *Energy Policy*, *38*(2), 887–895. https://doi.org/10.1016/j.enpol.2009.10.039

Cislaghi, B., & Cislaghi, C. (2019). SRH as a valid indicator for health-equity analyses: Evidence from the Italian health interview survey. *BMC Public Health*, *19*(1), 533. https://doi.org/10.1186/s12889-019-6839-5

Cook, J. T., Frank, D. A., Casey, P. H., Rose-Jacobs, R., Black, M. M., Chilton, M., decuba, S. E., Appugliese, D., Coleman, S., & Heeren, T. (2008). A brief indicator of household energy security: Associations with food security, child health, and child development in US infants and toddlers. *Pediatrics*, *122*(4), e867–e875. https://doi.org/10.1542/peds.2008-0286

Cornesse, C., Blom, A. G., Dutwin, D., Krosnick, J. A., De Leeuw, E. D., Legleye, S., Pasek, J., Pennay, D., Phillips, B., & Sakshaug, J. W. (2020). A review of conceptual approaches and empirical evidence on probability and nonprobability sample survey research. *Journal of Survey Statistics and Methodology*, *8*(1), 4–36. https://doi.org/10.1093/jssam/smz041

Demski, C., Poortinga, W., Whitmarsh, L., Böhm, G., Fisher, S., Steg, L., Umit, R., Jokinen, P., & Pohjolainen, P. (2018). National context is a key determinant of energy security concerns across Europe. *Nature Energy*, *3*(10), 882–888. https://doi.org/10.1038/s41560-018-0235-8

Diener, E., & Ryan, K. (2009). Subjective well-being: A general overview. *South African Journal of Psychology*, *39*(4), 391–406. https://doi.org/10.1177%2F008124630903900402

Dizard, J. (2021). Thrum and haze of diesel generators spreads across America. *Financial Times.* Retrieved January 11, 2022, from https://www.ft.com/content/c376b2fa-1af5-4920-88cf-27ac297ed8f2

Drehobl, A., & Ross, L. (2016). *Lifting the high energy burden in America's largest cities: How energy efficiency can improve low income and underserved communities.* Report. https://www.aceee.org/sites/default/files/publications/researchreports/u1602.pdf

European Social Survey (2016). ESS Round 8: European Social Survey Round 8 Data (2016). Data file edition 2.2. NSD - Norwegian Centre for Research Data, Norway – Data Archive and distributor of ESS data for ESS ERIC. doi:10.21338/NSD-ESS8-2016.

Frank, K. A., Maroulis, S. J., Duong, M. Q., & Kelcey, B. M. (2013). What would it take to change an inference? Using Rubin's causal model to interpret the robustness of causal inferences. *Educational Evaluation and Policy Analysis*, *35*(4), 437–460. https://doi.org/10.3102%2F0162373713493129

Goldemberg, J., Johansson, T. B., Reddy, A. K., & Williams, R. H. (1985). Basic needs and much more with one kilowatt per capita. *Ambio*, 14(4–5), 190–200.

Graff, M., Carley, S., & Konisky, D. M. (2018). Stakeholder perceptions of the United States energy transition: Local-level dynamics and community responses to national politics and policy. *Energy Research & Social Science, 43*, 144–157.

Gulliford, A. J. (1986). *Boomtown blues: A community history of oil shale booms in the Colorado River Valley*. Bowling Green State University.

Hainmueller, J. (2012). Entropy balancing for causal effects: A multivariate reweighting method to produce balanced samples in observational studies. *Political Analysis, 20*(1), 25–46. https://doi.org/10.1093/pan/mpr025

Healy, J. D. (2003). Excess winter mortality in Europe: A cross country analysis identifying key risk factors. *Journal of Epidemiology & Community Health, 57*(10), 784–789. http://dx.doi.org/10.1136/jech.57.10.784

Healy, J. D., & Clinch, J. P. (2002). Fuel poverty, thermal comfort and occupancy: Results of a national household-survey in Ireland. Applied Energy, 73(3–4), 329–343.

Hernández, D. (2016). Understanding 'energy insecurity'and why it matters to health. *Social Science & Medicine, 167,* 1–10. https://doi.org/10.1016/j.socscimed.2016.08.029

Hernández, D., & Siegel, E. (2019). Energy insecurity and its ill health effects: A community perspective on the energy-health nexus in New York City. *Energy Research & Social Science, 47*, 78–83. https://dx.doi.org/10.1016%2Fj.erss.2018.08.011

Holgado–Tello, F. P., Chacón–Moscoso, S., Barbero–García, I., & Vila–Abad, E. (2010). Polychoric versus Pearson correlations in exploratory and confirmatory factor analysis of ordinal variables. *Quality & Quantity, 44*(1), 153. https://doi.org/10.1007/s11135-008-9190-y

Houser, T., Bordoff, J., & Marsters, P. (2017, April). *Can coal make a comeback?* Report. New York: Columbia/SIPA, Center on Global Energy Policy.

Johnson, J. S. (2016). Improving online panel data usage in sales research. *Journal of Personal Selling & Sales Management, 36*(1), 74–85. https://doi.org/10.1080/08853134.2015.1111611

Lacroix, E., & Chaton, C. (2015). Fuel poverty as a major determinant of perceived health: The case of France. *Public Health, 129*(5), 517–524. https://doi.org/10.1016/j.puhe.2015.02.007

Lacroix, E., & Jusot, F. (2014, December). *Fuel Poverty is it harmful for health? Evidence from French health survey data.* [Conference paper]. Journées Des Économistes de La Santé Français (JESF). Bordeaux, France.

Lacy, M. G. (2006). An explained variation measure for ordinal response models with comparisons to other ordinal R^2 measures. *Sociological Methods & Research, 34(*4), 469–520. https://doi.org/10.1177%2F0049124106286329

Long, J. S., & Freese, J. (2006). *Regression models for categorical dependent variables using Stata*. Stata Press.

Lundberg, O., & Manderbacka, K. (1996). Assessing reliability of a measure of self-rated-health. *Scandinavian Journal of Social Medicine, 24*(3), 218–224. https://doi.org/10.1177/140349489602400314

Marquart-Pyatt, S. T., Qian, H., Houser, M. K., & McCright, A. M. (2019). Climate change views, energy policy preferences, and intended actions across welfare state regimes: Evidence from the European Social Survey. *International Journal of Sociology, 49*(1), 1–26. https://doi.org/10.1080/00207659.2018.1560979

Mayer, A., & Smith, E. K. (2019). Exploring the link between energy security and subjective well-being: a study of 22 nations. *Energy, Sustainability and Society, 9*(1), 1–13.

Memmott, T., Carley, S., Graff, M., & Konisky, D. M. (2021). Sociodemographic disparities in energy insecurity among low-income households before and during the COVID-19 pandemic. *Nature Energy, 6*(2), 186–193. https://doi.org/10.1038/s41560-020-00763-9

Mize, T. D. (2019). Best practices for estimating, interpreting, and presenting nonlinear interaction effects. *Sociological Science, 6*, 81–117.

Mood, C. (2010). Logistic regression: Why we cannot do what we think we can do, and what we can do about it. *European Sociological Review*, *26*(1), 67–82. https://doi.org/10.1093/esr/jcp006

Okosun, I. S., Choi, S., Matamoros, T., & Dever, G. A. (2001). Obesity is associated with reduced self-rated general health status: Evidence from a representative sample of white, black, and Hispanic Americans. Preventive Medicine, 32(5), 429–436.

O'Neill, D. W., Fanning, A. L., Lamb, W. F., & Steinberger, J. K. (2018). A good life for all within planetary boundaries. *Nature Sustainability, 1*(2), 88–95. https://doi.org/10.1038/s41893-018-0021-4

Ouedraogo, N. S. (2013). Energy consumption and human development: Evidence from a panel cointegration and error correction model. *Energy, 63*, 28–41. https://doi.org/10.1016/j.energy.2013.09.067

Rao, N. D., & Min, J. (2018). Decent living standards: Material prerequisites for human wellbeing. *Social Indicators Research, 138*(1), 225–244. https://doi.org/10.1007/s11205-017-1650-0

Reames, T. G., Daley, D. M., & Pierce, J. C. (2021). Exploring the Nexus of energy burden, social capital, and environmental quality in shaping health in US counties. *International Journal of Environmental Research and Public Health, 18*(2), 620. https://doi.org/10.3390/ijerph18020620

Roulin, N. (2015). Don't throw the baby out with the bathwater: Comparing data quality of crowdsourcing, online panels, and student samples. *Industrial and Organizational Psychology, 8*(2), 190–196. https://psycnet.apa.org/doi/10.1017/iop.2015.24

Schnittker, J., & Bacak, V. (2014). The increasing predictive validity of self-rated health. *PloS One, 9*(1), e84933. https://doi.org/10.1371/journal.pone.0084933

Sovacool, B. K. (2016). Differing cultures of energy security: An international comparison of public perceptions. *Renewable and Sustainable Energy Reviews, 55*(C), 811–822.

Steinberger, J. K., & Roberts, J. T. (2010). From constraint to sufficiency: The decoupling of energy and carbon from human needs, 1975–2005. *Ecological Economics, 70*(2), 425–433. https://doi.org/10.1016/j.ecolecon.2010.09.014

Sweidan, O. D., & Alwaked, A. A. (2016). Economic development and the energy intensity of human well-being: Evidence from the GCC countries. *Renewable and Sustainable Energy Reviews*, *55*, 1363–1369. https://doi.org/10.1016/j.rser.2015.06.001

Walter, S. L., Seibert, S. E., Goering, D., & O'Boyle, E. H. (2019). A tale of two sample sources: Do results from online panel data and conventional data converge? *Journal of Business and Psychology*, *34*(4), 425–452. https://psycnet.apa.org/doi/10.1007/s10869-018-9552-y

Watson, S. K., & Elliot, M. (2016). Entropy balancing: A maximum-entropy reweighting scheme to adjust for coverage error. *Quality & Quantity*, *50*(4), 1781–1797. https://doi.org/10.1007/s11135-015-0235-8

Williams, R. (2012). Using the margins command to estimate and interpret adjusted predictions and marginal effects. *The Stata Journal*, *12*(2), 308–331. https://doi.org/10.1177%2F1536867X1201200209

Xu, R., Frank, K. A., Maroulis, S. J., & Rosenberg, J. M. (2019). konfound: Command to quantify robustness of causal inferences. *The Stata Journal*, *19*(3), 523–550. https://doi.org/10.1177%2F1536867X19874223