Do Energy Burdens Contribute to Economic Poverty in the United States? A Panel Analysis

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ABSTRACT:
For many households, energy consumption represents a non-discretionary portion of their budget and directly relates to quality of life. As researchers continue to study the environmental impacts of energy behavior, it is important to explore how energy consumption relates to socio-economic wellbeing. This paper examines the economic impacts of being energy-burdened in the U.S., defined as spending at least 10% of household income on heating and electricity services; energy burdens are thus partially, but not entirely, driven by income, since energy needs and costs can vary substantially due to housing characteristics, utility rates, and other factors. Using panel data of U.S. household income and energy expenditures during 1999-2017, this analysis demonstrates that energy-burdened households were at about 150%-200% greater risk of transitioning into or extending the duration of economic poverty over a two-year timeframe relative to non-burdened households. This analysis indicates that dedicating inordinate amounts of income to energy services can threaten a household's economic well-being over time, possibly by preventing a household from engaging in other economic activities or compounding existing economic hardship. These results emphasize the importance of energy assistance and energy efficiency for low-income households, drawing attention to how structures of energy consumption, the welfare state, and social stratification intertwine.

INTRODUCTION

Energy consumption in the United States is often viewed in terms of excess. But energy scarcity—i.e., access to affordable energy—will become increasingly relevant if policies internalizing the environmental costs of energy production lead to increased prices and leave some households vulnerable to energy burden (Price, Brazier, and Wang 2012). Non-discretionary energy consumption can impose financial hardships for many U.S. households despite rationing and efficient behavior intended to minimize spending (Hernández and Bird 2010; Evens 2015). Rather than behavioral overconsumption, the financial burdens from energy use for these households primarily result from inefficient housing and insufficient capital to invest in improvements (Boardman 2012). Although scholarly attention to energy burdens in the industrial and post-industrial world is growing, fewer studies have examined energy burdens in the U.S. Given the relatively weak U.S. welfare state, where benefits often flow toward more affluent households (subsidizing for energy efficient appliances, for example), we should expect rising energy costs to push vulnerable populations to remain or fall into economic insecurity.

In this paper, we examine household energy costs in the U.S., focusing on households that spend 10% or more of their total income on heating and electricity. Using longitudinal data, this analysis investigates the relationship between household energy burden and vulnerability to future economic poverty. While households vulnerable to economic poverty are by definition vulnerable to energy burdens, we assume that since energy budgets are at least partly beyond the agency of individual households, they present barriers to activities that help households avoid or transition out of economic poverty. In other words, by demonstrating an association between energy burden and future economic poverty, this analysis suggests that energy burdens serve as an obstacle to preventing or transitioning out of poverty. We conclude with future lines of research considering these results, making connections between energy burden, social stratification, and environmental social science.

ENERGY BURDEN AND POVERTY

Transitions into poverty and economic insecurity constitute a vast and important area of research in sociology and related disciplines. Without reviewing this scholarship in full, it is fair to state that researchers often focus—with good reason—on changes to earnings and employment status as the predominant predictors of poverty entry (Bane and Ellwood 1986; Ruggles and Williams 1987; Jenkins 2000; McKernan and Ratcliffe 2005; Brady, Finnigan, and Hübgen 2017). In addition to these major factors, researchers have examined "trigger events" that put households at greater risk of poverty entry or bankruptcy, such as family dissolution, injury or ill health (DiPrete and McManus 2000; Smith 2004; Himmelstein *et al*. 2009; Maroto 2015; Tach and Eads 2015). Despite the rich body of work in this area, the complexity of unraveling the causal pathways to poverty entry leaves room for additional research connecting events to economic insecurity (Western *et al.* 2012).

Energy burdens may constitute a risk factor that has received less attention in existing research. Research on energy insecurity lends insight into how this experience may lead to future poverty spells. Hernández (2016) provided a conceptual framework, outlining the economic components of energy insecurity and the various burdens to which it exposes households. In addition to the health consequences of living in cold, dark, and damp conditions which can lead to debt accumulation or lost wages, Hernández found that many energy insecure residents prioritize housing payments and food costs over utility bills when forced to choose (a point reinforced by Finnigan and Meagher 2018). The resulting utility debt can lead to an economic cycle of “playing catch up.” Such debt can limit the ability to secure new housing as arrears can prevent the transfer of utility services to new addresses, potentially locking households into structurally inefficient homes and demanding resources that households could otherwise invest in avoiding or transitioning out of poverty (work-related capital, schooling or training, etc.). Utility disconnection is also linked with increased risk of eviction (Desmond 2016; Finnigan and Meagher 2018), food insecurity, telephone disconnection, unmet medical needs, and other forms of material hardship (Heflin 2006).

In the case of eviction, Desmond’s (2016) qualitative research in Milwaukee, Wisconsin finds that evictions spike in the summer and early fall when low-income households prioritize catching up on their utility bills to avoid disconnection before the winter shut-off moratorium begins, and evictions decline over the winter when households can stop paying their utility bill without risking a disconnection. Interviews conducted by Hernández (2016) of low-income families revealed utility bills cumulating to thousands of dollars, restricting discretionary income and putting households into long-term debt. In their ethnographic research, Harrison and Popke (2011) shed light on the challenges of energy-burdened households deciding between paying utility bills and covering their medical and nutritional needs.

At a meso-level, the experience of energy burden can prevent families from moving out of low-resource neighborhoods and establishing social connections that facilitate economic opportunity. While social networks can provide private safety nets that help mitigate the consequences of triggering events (Heflin, London, and Scott 2011), a large majority of Americans experiencing missed utility payments report receiving no outside help; of those who do, about half receive support from friends and family (Finnigan and Meagher 2018). Researchers have linked inadequate access to affordable energy with household food insecurity

(Cook *et al*. 2008; Bhattacharya *et al*. 2003), health and child development risks (Cook *et al*. 2008; Hernández 2013; Hernández 2016), social network disruption (Harrison and Popke 2011), and mortality during heat waves (Klinenberg 2002).

The trade-off between paying energy bills and sacrificing basic needs is documented across several pieces of research. A U.S. Energy Information Administration report indicated that about a third of households faced challenges in paying their energy bill in 2015, and about a fifth of households reduced or forwent basic necessities for at least a month to pay their energy bill (U.S. EIA 2015a). A whitepaper produced for the Senate Committee on Energy and Natural Resources explored how energy costs can push families to poverty entry or cause food insecurity (Murkowski and Scott 2014). A statewide report in Colorado found the inability to pay utility bills as one of the leading causes of homelessness behind job loss and family breakup (Center for Education Policy Analysis 2006). Utility shutoffs can exacerbate or cause illness (Hernández and Bird 2010), and landlords may use disconnection as grounds for eviction in some circumstances (Verclas and Hsieh 2018).

Eviction, food insecurity, and other material hardships often associated with energy burdens could initiate or prolong a cycle of poverty. The inability to access affordable energy services can prevent participation in certain economic activities and serve as a barrier to upward mobility (Sovacool, Sidortsov, and Jones 2014). We suggest that energy burdens may be one of several triggering events preceding poverty entry (Bane and Ellwood 1986; DiPrete and McManus 2000).

The concept of energy burden provides a structure for theoretical and empirical analysis of energy access and its implications for human welfare. We can conceptualize energy burden in terms of access to affordable, safe, and sufficient energy services or as a disproportionate (and non-discretionary) share of household resources dedicated to energy needs. A key part of this concept is that, to a certain extent, energy consumption is non-discretionary. Just as some basic amount of food consumption is essential for human welfare, some basic amount of energy consumption is essential for maintaining well-being, such as for heating and cooling, cooking, and lighting. Households are constrained in how much energy use can be reduced without compromising health and well-being, while energy efficiency improvements can both reduce energy needs and improve health (Wilson *et al*. 2016; Büchs *et al*. 2018). Various researchers have defined burdens in terms of actual expenditures using 6%, 10%, or 20% thresholds, estimated energy costs associated with heating a home to a particular temperature, or combinations of high costs with low incomes (Boardman 1991; APPRISE 2005; Moore 2012). While energy burdens are clearly linked with income and thus economic poverty, the two are not perfectly aligned. Moderate income households may be susceptible to energy burdens just as households living in economic poverty are not necessarily dedicating a large share of their income to energy needs. Furthermore, focusing on expenditures fails to capture energy rationing among lower income households; energy expenditures are thus distinct from "affordable warmth" discussed in the fuel poverty literature (Boardman 2010), which takes into account necessary costs to reach a particular temperature.

The amount of total income resources dedicated to energy varies across class boundaries, with middle- and upper-income households typically spending 5% or less while poor households may spend 10%, 20%, or even greater proportions of their income on energy services (Evens 2015; Drehobl and Ross 2016). Income dedicated to energy services limits the resources available for other actions, so fluctuating energy costs can greatly affect resources available to satisfy other basic needs, including food (Bhattacharya *et al*. 2003). At the same time, energy consumption does not increase in a simple linear fashion with income, and some low-income households use more energy per square foot of housing space due to less efficient appliances and temperature control systems (Evens 2015, using electricity data for Chicago-area households).

Qualitative research in the U.S. indicates that low-income households experiencing high energy burdens are not profligate in their behavior, displaying high levels of rationing energy consumption in everyday life. Some low-income households restrict energy use to the point where they are unable to maintain World Health Organization recommended minimum home temperatures (Hernández and Bird 2010; Middlemiss and Gillard 2015). The relationship between energy burden and poverty is not simply a matter of income, but also a function of home characteristics and related factors that influence energy needs (the Methodology section provides further details on the correlation between energy burdens and poverty). Research in the U.K. has identified constraints on controlling energy costs driven by: housing quality; tenancy relations and the "split incentive" problem (see below for details); utility rates (which vary substantially across the U.S.) as well as fees and debt; and non-negotiable energy needs of household members (Middlemiss and Gillard 2015). Poverty clearly increases the likelihood of energy burden simply due to low income but may also exacerbate energy burden on the cost side through these factors. Recent research has found that energy use intensity, or the consumption of heating or cooling energy per square foot of living space, is higher in lower income neighborhoods in Detroit, Michigan (Bednar, Reames, and Keoleian 2017) and Kansas City, Missouri (Reames 2016). On the other hand, experiencing energy burden may place a household at greater risk of poverty, since reduced discretionary funds can limit a household's ability to invest in education, job training or economic capital, or make contributions to savings. Energy burdened households may become vulnerable to utility debt, further adding to these constraints.

Parallel research on housing affordability has found that families facing housing cost burdens (commonly defined as costs greater than 30% of household income) face a variety of challenges: increased odds of poor self-rated health and various medical conditions (Pollack, Griffin, and Lynch 2010); less ability to invest in child education (Newman and Holupka 2014); and less money set aside in savings (Mendenhall, Kramer, and Akresh 2014). Like housing costs, energy costs are at least partially fixed and essential to household wellbeing. Although energy costs are usually substantially smaller than direct housing costs (i.e. rent, mortgage payments), higher energy costs nonetheless reduce discretionary funds and likely impact low-income families in similar ways to housing cost burdens. Additionally, housing is a productive asset that can support investments in social or human capital, or generate income (Moser 1998). Applying the asset vulnerability framework, energy inefficient housing may less effectively guard against poverty spells.

In general, housing is a critical factor on both the energy and poverty sides and has a significant impact on household energy needs. Tenants in rental housing face additional hurdles to managing their energy costs, since they are typically unable to invest in energy efficiency upgrades for their homes. This situation compounds behavioral and other barriers to energy efficiency that poor households face, since most households within 150% of the federal poverty level reside in rental housing and about 75% of renters pay their own utility bills (U.S. EIA 2015b). From an ownership standpoint, landlords have minimal incentive to improve the energy efficiency of the units they oversee. This falls under a "split incentive problem" where landlords do not accrue direct benefits from their investments in energy efficiency while occupants responsible for paying energy bills do not have the opportunity to make structural changes to their dwelling (Gillingham, Newell, and Palmer 2009; Hernández and Bird 2010). Thus, the rental homes that many poor households occupy are often less efficient and subject to higher energy costs for heating and cooling, which may contribute to higher levels of energy rationing and less healthy home temperatures (Gillingham, Harding, and Rapson 2012; Middlemiss and Gillard 2015).

ENERGY ASSISTANCE AND THE WELFARE STATE

The U.S. has had a federally coordinated energy assistance policy since 1981, when the Low Income Home Energy Assistance Program (LIHEAP) was established to assist low income households in meeting their home energy needs. The most common LIHEAP qualification threshold for household income is 150% of federal poverty guidelines, although many states use other thresholds. LIHEAP typically covers only a small portion of total energy bills and has historically reached only a fraction of eligible households, between 10% and 20% (LIHEAP 2000; Kaiser and Pulsipher 2006). There are various other federal, state, local, and utility programs that encourage energy efficiency and renewable energy or provide assistance to low-income households. However, assistance programs generally do not have sufficient funds to serve all applicants, while energy efficiency programs often require partial payments from customers that present a barrier to low-income households (Evens 2015).

Since Lutzenhiser and Hackett's (1993) call for sociologists to connect environmental problems and energy with stratification and social welfare, relatively few scholars have answered. Welfare state research includes diverse contributions on tax systems (Prasad 2011; 2012), health care reform (Hacker 2004), and other topics, but little consideration to date regarding energy burdens. A comprehensive review of the welfare state literature lies beyond the scope of this paper, but it is worth highlighting the theoretical framework developed by Weir, Orloff, and Skocpol (1988), who explain the relatively weak U.S. welfare state in terms of institutional structure: unlike the centralized bureaucratic states of Western Europe and their comparatively generous welfare expenditures, regional patronage networks and piecemeal bureaucratic-professional reforms characterize U.S. history, preventing a robust welfare state from developing. Consistent with this, Hacker (2002) and Mettler (2011) both emphasize the extent to which U.S. policy operates via indirect benefits (a tax break rather than direct provision, for example), which can easily fail to reach vulnerable populations in favor of the relatively affluent. These perspectives are also consistent with the various energy efficiency and clean energy tax credits and deductions, and the fact that these benefits primarily go to wealthy households (Borenstein and Davis 2016). Given such trends, we should expect that many households negatively impacted by energy burdens find insufficient welfare state resources available to help, and the patchwork of federal, state, local, and utility programs are unlikely to fill the gap (Evens 2015).

We can logically assume that at the level of households, transitioning into economic poverty and the lower income it entails will increase the likelihood of experiencing energy burden. If the transition into economic poverty is preceded by a loss of household income, then—following the logic of Engel's law of food elasticity (Engel 1857)—we can assume that the share of income dedicated to energy consumption will rise above operational definitions of energy burden. Yet the reverse direction has not been investigated, leading to the key research question here: does energy burden increase the likelihood of extending or entering economic poverty? In this analysis we test the hypothesis that it does. Given the relatively non-discretionary nature of energy consumption, the cycles of debt energy burdens can initiate, and the social and health consequences of energy insecurity, we expect to find connections between energy burdens and future economic poverty status.

DATA

Data for this project come from the Panel Study of Income Dynamics (PSID), a longitudinal survey of households that began in 1968 with an initial sample of nearly 5,000 U.S. families. Data for this analysis come from household energy consumption gathered between 1999 and 2017 (waves 31 - 40).

Three measures of poverty serve as dependent variables, using income thresholds for defining poverty according to whether a household lives within 100%, 150%, or 200% of per capita household poverty guidelines contained in the PSID. These thresholds are based on detailed poverty tables from the Census Bureau that account for family size and number of related children.[i,ii] (In 2017, families of four with two children and a total income of $24,944 or less fell within 100% of poverty guidelines.) Most households living within 150% of the poverty level qualify for LIHEAP subsidies, although different states use different thresholds.[iii] Additionally, it is common practice when using PSID data in particular to operationalize poverty at greater than 100% of federal guidelines (Cellini, McKernan, and Ratcliffe 2008) or when studying U.S. poverty in general to analyze it according to multiple indicators (Ruggles 1992).

Respondents were asked how much they spend on heating or gas fuel and electricity per month.[iv] Although energy costs are expected to fluctuate across seasons, the PSID survey does not capture this seasonality but instead asks about typical monthly costs.[v] To test the effect of energy burden, this amount was calculated as a share of total household monthly income from the previous year. A dummy variable was created with 1 = households that spend at least 10% of their monthly income on heat and electricity combined, conceptualized as households that face energy burdens. Respondents whose utility bills are included in their rent were dropped from analysis (accounting for about a fifth of all renters). This metric uses energy expenditures, and does not account for the level of energy use necessary for a household to maintain healthy home temperatures, such as the "low income/high cost" measurement modeled by Hills (2011). The PSID data likely suffer from a "rounding strategy" used by respondents to self-report consumption expenditures (Pudney 2008), although the binary measure of energy burden should minimize this concern. Additionally, the PSID does not instruct respondents in how to handle utility subsidies when estimating monthly expenditures. Other independent variables are included to control for common predictors of poverty status. Since loss of income is an obvious potential cause for entering economic poverty, a dummy variable was created where 1 = a loss of at least 10% of household income from the previous wave. Ill health status was measured according to whether household heads assessed their health as fair or poor, with "good health" (those self-assessing as excellent, very good, or good) as the reference category. Both concurrent and lagged ill health were analyzed to control for the impacts of household heads' ill health on economic wellbeing over time.

Several dummy variables were created to account for social structural location. These include whether household heads are female (which is time-varying in cases where female respondents become household heads for the first time), young (under 30), senior (65 or older), college graduates, and own their home. Dummy variables were also created for the type of health insurance a respondent had: private health insurance, other health insurance (provided for military veterans, e.g.), Medicare and/or Medi-Gap, or Medicaid, with uninsured as the reference category. Since economic poverty is measured on a per capita basis, new additions to the family unit could qualify a household as living in poverty even if their income remains stable. To account for this, a dummy variable was created where 1 = households that reported new family members since the previous wave. Marital status is also controlled for, with concurrent dummy variables accounting for whether the household head is married, divorced, separated, or widowed, with single as the reference category. Lagged variables for marital status are not included because of likely collinearity with Female head of household: since the PSID defined the head of household as male for all opposite-sex married or long-term cohabitating couples across all but the most recent wave included in this analysis, a household that transitions from a male head in a previous wave to female head concurrently would also experience a related change in marital status. Table 1 shows descriptive statistics of variables used in this analysis.

—Insert Table 1 about here—

METHODOLOGY

A challenge of this research area is the role of income: it determines whether a household falls below the poverty thresholds, and by definition, energy burden is a function of income. Income is therefore part of the outcome (i.e. poverty), and included among the predictors as a component of energy burden. To address this mechanical correlation, we restrict inclusion of energy burden to its lagged state (two years prior), so that income is not used to calculate both concurrent poverty status and state of energy burden. When inspecting the relationship between lagged energy burden and corresponding poverty status after each model, all correlations were below 0.11.

Furthermore, by themselves these poverty thresholds explain only a small proportion of the variation in energy burdens: we ran a series of logistic regressions predicting energy burden from different levels of poverty, predicting energy burden from total family income, and predicting each level of poverty from energy burden, resulting in a pseudo r^2 between 0.2 – 0.3. In other words, we cannot characterize the relationship between poverty and energy burden as a simple mechanical or spurious correlation due to low income. While our measure of energy burden is operationally tied to income, as is poverty, these data support our arguments that energy burden and poverty are neither conceptually nor empirically reducible to each other, and thus it is appropriate to use them in the same statistical model.[vi] This characterization is consistent with research on material hardship; although income loss is obviously and consistently related to medical, food, or housing hardship, such experiences are not reducible to income alone and can also be impacted by factors such as changes in health status, caring for family members with a disability, or drug use (Heflin and Butler 2012; Heflin 2016).

Given the binary dependent variables and panel structure of the PSID data, fixed effects logistic regression is utilized in this analysis (Allison 2009). Fixed effects models offer the ability to measure within-unit change in the outcome over time, taking the following form:

$$\log\left(\frac{p_{it}}{1-p_{it}}\right) = \mu_t + \beta \mathrm{X}_{it} + \gamma \mathrm{Z}_i + \alpha_i, \;\; t = 1, 2 \ldots, T$$

where *p* refers to the probability of household *i* at time *t* of displaying a positive outcome, μ is the intercept that may vary over time, X represents a vector of time-varying predictors, Z represents a vector of time-invariant predictors, and α represents the total effects of unobserved variables that remain constant over time. One consequence of restricting analysis to within-unit change is the inability to estimate time-constant variables such as race. Additionally, any unit that displays no variation in the outcome over the course of data collection is dropped from analysis. However, if researchers can partial out unobserved and time-constant heterogeneity while focusing on within-unit change in the outcome, they can make stronger claims to causal inference not available with cross-sectional survey analysis. While it is difficult to make direct claims about causality with observational data, by establishing a statistically significant relationship between dependent and independent variables, accounting for omitted variable bias, and establishing a temporal ordering of events, fixed effects panel designs offer more rigorous analysis than cross-sectional approaches (Finkel 1995; Frees 2004).

An additional challenge regards distinguishing between poverty entry and poverty extension. Prior and current states of poverty are correlated. To understand the relationship between energy burden and poverty status, it is important to know whether prior experience with energy burdens increases the likelihood of new entry into poverty, extends the duration of poverty, or both. With continuous outcomes, researchers often address this by estimating dynamic panel models that include lagged states of the dependent variable as predictors, using Arellano-Bond estimators to deal with resulting bias (Arellano and Bond 1991). However, there is less consensus regarding dynamic logit models. Instead of including lagged dependent variables as predictors, and taking inspiration from Stewart and Swaffield's (1999) study of low pay transitions in Britain, we restrict samples to whether a household was below a poverty threshold at the previous wave (models predicting the endurance of poverty), or above a poverty threshold at the previous wave (models predicting poverty entry). Sociologists working with repeated binary outcomes characterized by state dependence should consider adopting this stratifying approach, which is not commonly employed in the discipline.

Temporal ordering is established through the inclusion of lagged independent variables, including energy burden. For all models, unstandardized regression coefficients are presented in tables, while substantive discussion reports odds ratios. Finally, we ran sensitivity tests with several alternative model specifications:

- The addition of geographic controls, specifically fixed effects for state of residence.
- Operationalizing energy burden at 6% rather than 10% of household income, and as a continuous variable, to account for the depth of energy burden.
- The addition of housing type (single family homes, mobile homes, multiunit structures).
- The addition of subsidies for rental housing and heat (as a continuous variable; about 5% of the sample received a government-funded heat subsidy, with an average annual payment of $390).[vii]
- A subset model: predicting 100% poverty within the population of families with income below 200% of the poverty threshold. This approach was used as an additional check regarding the role of income.

Results for these alternative model specifications were consistent with the results presented below. Stata code for the full analysis is available online.

RESULTS

Table 2 presents results from fixed effects logistic regression estimating whether households fall within various poverty thresholds, restricted to households below the corresponding poverty level at the previous wave. These models represent whether a household endures a poverty status across concurrent waves. For context, most households in the positive outcome for Models 1 and 2 qualify for federal heating assistance.

—Insert Tables 2 and 3 about here—

The key variable of interest—whether a household was energy-burdened in the prior wave—is statistically significant in all models. Net of other factors, we see in Model 1 that energy-burdened households had about 175% greater odds of remaining in poverty two years later relative to their non-burdened peers. In Model 2 among households previously within

150% of the poverty threshold and net of other factors, those with prior energy burdens were about twice as likely of enduring this economic status compared with households without prior energy burdens. In Model 3, we again see the impact of prior energy burdens resulting in over 100% greater odds of enduring a status below 200% of the poverty threshold. As noted above, this energy burden metric does not account for rationing or the level of energy use needed to maintain healthy home temperatures. Given the energy rationing described in qualitative studies, if data were available to capture the higher cost of "necessary" energy use, we would likely see an even more deleterious impact on economic status.

Several household demographics historically associated with economic poverty are controlled in these models. Unsurprisingly, adding new family members increased the odds of staying in poverty. Women who became new household heads had about triple the odds compared with male household heads of staying within 100% of the poverty threshold.

Focusing on transitions into poverty, Table 3 presents results from fixed effects logistic regression, restricted to households above the corresponding poverty level at the previous wave. Across all three models, lagged energy burden had a statistically significant relationship to concurrent poverty status. Relative to non-burdened households, those with prior energy burdens had about double the odds of transitioning into poverty (Model 4), 150% greater odds of transitioning within 150% of the poverty threshold (Model 5), and about 60% greater odds of transitioning within 200% of the poverty threshold (Model 6). The impact of prior energy burdens on concurrent poverty status again accounts for whether a household experienced a substantial loss in income, which is obviously the single largest driver of the outcome across all models.

As with Models 1-3, Models 4-6 control for a variety of other variables commonly associated with transitions into economic poverty. Both married and divorced heads of household were less likely to transition into poverty relative to single household heads. Likewise, owning a home or graduating from college were positive predictors of economic wellbeing.

Although a full discussion of the role of health is beyond the scope of this paper, it is worthy to note the impact of health on economic wellbeing. In Model 4, for example, household heads rating their subjective health as fair or poor had about 20% greater odds of entering poverty two years later, compared to their counterparts rating their health as good, very good, or excellent. Concurrently having private health insurance predicts economic wellbeing. This is consistent with other research suggesting that access to health insurance through the Affordable Care Act marketplace may lower home mortgage delinquency rates (Gallagher *et al*. 2017), and is aligned with research linking maternal health with entrance into material hardship in the forms of food insufficiency, utility disconnections, unmet medical needs, and housing problems (Heflin 2013).

DISCUSSION

These results clearly point to the economic disadvantage faced by energy-burdened households. As policymakers and activists continue to address energy consumption as part of climate change mitigation, it is important to recognize how increased energy prices could affect economically vulnerable households. Impacts from increased energy costs can be immediate, for instance if a household reduces expenditure on other necessities in order to heat the home (Bhattacharya *et al*. 2003), or when a household falls behind on their utility bills and consequently harms their credit rating (see Fourcade and Healy 2013 on the stratifying effect of credit ratings in the U.S.). Activists and policymakers should keep in mind that too many households lack a proper safety net to secure them from policies that increase energy costs. For researchers and theorists, this analysis highlights how energy burdens may act as triggering events for poverty entry and draws attention to the inadequacy of welfare state programs addressing this. We hope this analysis points to how energy consumption, the welfare state, and social stratification are intertwined.

Environmental activists, program implementers, and policymakers should keep these energy equity issues in mind when confronting potential transitions to cleaner energy. For example, programs offering energy efficiency or clean energy services for low-income households can simultaneously work toward economic equity (by ensuring access to affordable energy) and environmental mitigation (by ensuring cleaner and/or more efficient energy consumption), social concerns historically brought up by Lutzenhiser and Hackett (1993). Ideally, renewable energy and energy efficiency programs would be accessible to low-income households, with funding assistance if necessary, since utility hardships are linked with other forms of hardship and assistance may reduce risks in other areas (Finnigan and Meagher 2018). In reality, activists and policymakers need to consider energy burdens in three policy areas: energy assistance, energy efficiency programs, and clean or renewable energy programs.

These results demonstrate that the benefits of energy efficiency and weatherization could extend beyond energy use to include reduced risk of economic poverty. For example, home insulation can last 80 years or more, effectively serving the duration of residency for a given household. Direct energy assistance may offer similar benefits in the short term, although future research should confirm that direct and weatherization assistance can mitigate the results found in this analysis. In terms of program design, high-quality and well-funded low-income energy programs may help reduce the risk of economic poverty while supporting environmental, climate, and other goals. We suspect, however, that current funding levels for LIHEAP and weatherization programs insufficiently mitigate inadequate energy access, at least at the federal level. Historically, LIHEAP and federal weatherization assistance funding has served only a fraction of eligible households (Higgins and Lutzenhiser 1995), although it can be a critical form of assistance for those who receive it (Murray and Mills 2014), and federal weatherization assistance programs have reduced energy bills by 12% on average (U.S. DOE 2015). Nonetheless, policy or activist efforts to address climate change mitigation could consider energy consumption as a site of intersection that simultaneously addresses social and environmental concerns (Hernández 2015).

To maximize the benefits of energy efficiency programs, these programs must be accessible to low-income households. This potentially requires greater funding for direct assistance or to address building health and safety issues that must be fixed before a retrofit can safely proceed (Scheu *et al*. 2018). Furthermore, to the extent that low-income households engage in energy rationing, low-income efficiency programs may see smaller energy savings but greater benefits in terms of healthy home temperatures and other non-energy benefits. For energy efficiency programs to be accessible to renters, these programs need to target multifamily building owners. Landlords remain key to the reform of energy consumption. Bird and Hernández (2012) suggest incentivizing landlords to take on energy efficiency upgrades for their units by covering the cost of loan financing in exchange for committing their property to low-income renting for the period of the loan. Future research could help encourage multifamily energy efficiency by evaluating the benefits for landlords who do not pay utility bills, for instance more comfortable housing units that reduce tenant turnover and increase net operating income for the building (Philbrick *et al*. 2016). Energy efficiency programs targeting multifamily buildings can offer services to a significant share of low-income renters. For example, in Chicago 59% of multifamily housing units are in low-cost, low-income neighborhoods or are subsidized (Corso, Garascia, and Scheu 2017), and programs targeting these buildings may reduce energy burdens among low-income tenants. Research in the U.K., however, indicates that income poverty spells typically last longer than fuel poverty (consistent with data used here), although rates of long-term fuel poverty exit vary across rural/urban settings, indicating that policies targeting housing stock may see inconsistent results (Roberts *et al*. 2015). Nonetheless, improving the efficiency of low-income housing will likely produce environmental benefits while potentially reducing the risk of energy burdens triggering poverty entry.

In addition to implications for activists, policymakers, and program implementers, these results also point to several fruitful directions for further research. We suspect the relationship between energy burden and economic poverty reflects multiple points of vulnerability and resource constraints relating to physical housing structure, neighborhood context, and consequences for social networks, physical health, or mental health. Energy burdens are under-studied and need much more attention from social researchers to refine the mechanisms that connect this experience with poverty, and to understand the myriad coping strategies households employ. Comparative research could illuminate the effectiveness of policies and programs in mitigating these problems.

Other research areas could benefit from considering energy burdens as possible mechanisms, moderators, or complicating factors for other relationships. As one example, these results could hold implications for research on environmental risk perceptions and support for clean energy. Overall, lower-income individuals perceive greater long-term environmental risks than higher-income individuals (Trumbo *et al*. 2011; Lo 2014). Researchers could inquire how energy insecurity affects support for clean energy or climate change mitigation policy, particularly when those policies may result in slightly higher energy prices or inequitable impacts on consumers. Although renewable energy costs have fallen dramatically and are near parity with the cost of other fuels (Lazard 2016), carbon taxes or related instruments may nonetheless contribute to higher energy costs for some consumers, or the perception of higher costs. Additionally, tax credits and rebates for clean energy technologies can exacerbate inequity because upfront costs or credit requirements make them accessible primarily to the rich: 60% of U.S. clean energy tax credits have gone to the top income quintile (Borenstein and Davis 2016). It is thus important to understand how perceptions of energy burdens or inequities affect support for social and environmental change. Energy justice could be crucial for working toward the goals held by mainstream environmentalists and clean energy movements.

Along this line of thought, several topics are proposed for future research to extend insights into energy burdens in the U.S.:

1. Does the experience of energy burden erode support for clean energy (assuming clean energy options are perceived as more expensive than conventional energy options)?
2. To what extent does energy consumption constitute a barrier to social mobility if basic needs exceed energy burden thresholds? How does energy burden compare to equivalent concepts of food and housing cost burden in terms of volatility and temporal patterns, and interrelationships? What are the relative impacts on poverty and social mobility of these and other independent causes of poverty?
3. In what ways does experiencing an energy burden contribute to poverty, and do the mechanisms vary in meaningful ways? What are the roles of housing (physical structure as well as affordability), health, financial constraints, cognitive capacity (Mani *et al*. 2013), utility rates and disconnection policies, and other factors?
4. What is the role of utility assistance, low-income weatherization assistance, LIHEAP, or other energy programs in moderating the relationship between energy burden and poverty? Do the programs that have the largest and longest-lasting impact on reducing energy use (e.g. weatherization) also have a large impact on reducing energy burden?

The first question brings a concern from social stratification (financial hardship) into the realm of environmental sociology and related social science by opening an analysis of support for clean energy development. The second question brings a concern from environmental sociology (energy consumption) into the realm of social stratification and material hardship and ties energy policy to broader poverty alleviation efforts, while the third question delves deeper into the processes that link energy and financial hardships. The fourth question addresses a potential moderating factor in that relationship and may have implications for program design and our theoretical understanding of the welfare state.

When analyzing energy consumption in the U.S., sociologists typically focus on excessive use. But household energy scarcity could constitute an important topic for environmental sociology and social science more broadly, particularly in contexts where natural resource consumption to meet basic needs results in financial hardship. Sociological research in general would benefit from greater attention to energy burden and energy insecurity, in terms of financial hardships as well as variation in utility rates[viii], the impact of utility disconnection, the intersection of housing and energy, and other topics. This presents an opportunity for social scientists to engage in a larger discourse about social inequality that will be crucial to future conversations about energy and climate policy.

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Table 1 – Descriptive statistics.

Variable	Proportion (200% poverty rate$_{t-1}$ = 1)	Proportion (200% poverty rate$_{t-1}$ = 0)
Energy burdened$_{t-1}$	0.46	0.09
10% income loss	0.23	0.45
Ill health	0.23	0.14
Private Insurance	0.24	0.44
Other Insurance	0.03	0.03
Medicaid	0.20	0.06
Medicare	0.04	0.05
New family member	0.19	0.18
Married	0.53	0.68
Divorced	0.14	0.11
Separated	0.07	0.05
Widowed	0.05	0.04
Homeowner	0.49	0.68
Female HH	0.39	0.23
Young HH	0.19	0.17
Senior HH	0.07	0.08
College grad	0.11	0.26

Table 2 – Unstandardized coefficients (and robust standard errors) for time-varying predictors from fixed effects logistic regression predicting different levels of poverty among households below the corresponding poverty level at the previous survey wave. Models control for year (not displayed).

	Model 1: *100% poverty rate$_{t-1}$ = 1*		***Model 2:*** *150% poverty rate$_{t-1}$ = 1*		***Model 3:*** *200% poverty rate$_{t-1}$ = 1*	
	Coef.	Robust St. Err.	Coef.	Robust St. Err.	Coef.	Robust St. Err.
Energy burdened$_{t-1}$	1.019***	0.090	0.674***	0.06	0.761***	0.048
10% income loss	3.286***	0.132	3.219***	0.099	3.139***	0.093
Ill health$_{t-1}$	0.210*	0.097	0.064	0.065	0.035	0.057
Ill health	0.080	0.083	0.223***	0.064	0.039	0.054
Private Insurance$_{t-1}$	-0.593***	0.175	-0.232*	0.099	0.108	0.076
Private Insurance	-0.682***	0.157	-0.338***	0.086	-0.431***	0.068
Other Insurance$_{t-1}$	1.148***	0.218	0.581***	0.139	0.516***	0.129
Other Insurance	0.189	0.200	0.100	0.15	0.202	0.133
Medicaid$_{t-1}$	0.247*	0.106	0.108	0.076	0.466***	0.07
Medicaid	0.487***	0.100	0.692***	0.074	0.686***	0.071
Medicare$_{t-1}$	0.412	0.220	0.366*	0.158	0.328*	0.15
Medicare	0.198	0.220	0.576***	0.155	0.373**	0.137
New family member	0.194*	0.092	0.045	0.059	0.195***	0.05
Married	0.192	0.198	0.907***	0.148	0.266*	0.115
Divorced	-0.716***	0.201	-0.716***	0.14	-0.400***	0.107
Separated	-0.079	0.180	-0.072	0.157	-0.282*	0.127
Widowed	-0.942***	0.266	-0.571**	0.203	-0.201	0.177
Homeowner$_{t-1}$	-0.485***	0.122	-0.100	0.086	-0.310***	0.068
Homeowner	-0.269*	0.111	-0.233**	0.079	-0.443***	0.067
Female HH	1.286***	0.205	1.842***	0.153	1.081***	0.11
Young HH	-0.326**	0.101	-0.286***	0.074	-0.207**	0.065
Senior HH	-0.060	0.279	0.159	0.168	0.813***	0.145
College grad	-1.034***	0.254	-1.073***	0.134	-0.772***	0.112
N	7,971		13,982		19,589	

* p<0.05, ** P<0.01, *** P<0.001

Table 3 – Unstandardized coefficients (and robust standard errors) for time-varying predictors from fixed effects logistic regression predicting different levels of poverty among households above the corresponding poverty level at the previous survey wave. Models control for year (not displayed).

	Model 4: *100% poverty rate$_{t-1}$ = 0*		***Model 5:*** *150% poverty rate$_{t-1}$ = 0*		***Model 6:*** *200% poverty rate$_{t-1}$ = 0*	
	Coef.	Robust St. Err.	Coef.	Robust St. Err.	Coef.	Robust St. Err.
Energy burdened$_{t-1}$	1.109***	0.068	0.921***	0.072	0.453***	0.076
10% income loss	4.050***	0.087	3.598***	0.067	3.091***	0.054
Ill health$_{t-1}$	0.243***	0.07	0.028	0.066	0.144*	0.069
Ill health	0.157*	0.066	0.248***	0.064	0.184**	0.064
Private Insurance$_{t-1}$	-0.072	0.085	0.015	0.076	0.093	0.072
Private Insurance	-0.546***	0.083	-0.448***	0.071	-0.329***	0.064
Other Insurance$_{t-1}$	0.103	0.186	0.440**	0.162	0.501**	0.152
Other Insurance	0.540***	0.146	0.459**	0.145	0.636***	0.140
Medicaid$_{t-1}$	0.098	0.093	0.619***	0.098	0.744***	0.113
Medicaid	0.642***	0.084	0.576***	0.083	0.814***	0.092
Medicare$_{t-1}$	0.060	0.171	0.316*	0.155	0.182	0.133
Medicare	0.105	0.157	0.194	0.139	0.131	0.123
New family member	0.499***	0.067	0.702***	0.060	0.714***	0.056
Married	-0.743***	0.112	-0.596***	0.095	-0.657***	0.098
Divorced	-0.407***	0.117	-0.692***	0.113	-0.345**	0.117
Separated	-0.729***	0.125	-0.477***	0.122	-0.043	0.138
Widowed	-0.369*	0.187	-0.032	0.170	0.038	0.180
Homeowner$_{t-1}$	-0.152*	0.071	-0.205**	0.067	-0.055	0.067
Homeowner	-0.702***	0.072	-0.903***	0.067	-0.859***	0.061
Female HH	0.319**	0.101	0.695***	0.098	0.272**	0.094
Young HH	0.379***	0.074	0.401***	0.071	0.440***	0.069
Senior HH	-0.039	0.156	0.044	0.136	0.071	0.126
College grad	-0.722***	0.111	-0.659***	0.095	-0.499***	0.086
N	23,531		28,517		30,406	

* p<0.05, ** P<0.01, *** P<0.001

ENDNOTES

[i] The models predicting income of 150% and 200% of poverty thresholds are included to address concerns in the literature that the 100% threshold is too low and reflects outdated modes of consumption. A full discussion of this issue is beyond the scope of this paper, but see e.g. Ruggles (1990, 1992) and Blank (2008). Additionally, since many states use 150% and 200% thresholds to determine qualification for energy assistance, it makes sense to extend analysis to these levels.

[ii] Although the Supplemental Poverty Measure could account for differences in cost of living, it was not published by the U.S. Census until 2011 and thus not available for many of the PSID waves analyzed here.

[iii] Another common threshold is 60% of the state median income, which is often higher than 150% of the federal poverty guideline, and some states extend the threshold to 200% of the poverty level. The LIHEAP Clearinghouse provides eligibility details for each state: https://liheapch.acf.hhs.gov/snapshots.htm

[iv] Before 2011 this question asked about "gas or other types of heating fuel", and was revised in 2011 to "gas and other types of fuel". There are other small changes in PSID question wording over time, which we do not believe are likely to influence results. Models restricted to 1999-2009 produce results consistent with the models presented here.

[v] There still may be a seasonal aspect to these data because respondents provide different estimates of typical monthly costs depending on when you ask them (e.g. average gas costs among respondents interviewed in March-May is $164, versus $157 in June-August). We ran basic one-way ANOVA tests for the influence of interview season, defining winter as December through February and summer as June through August, which is aligned with heating and cooling months for most of the U.S. These models found a statistically significant effect of interview season on heating costs and electricity costs (both $p<0.001$), and a marginally significant effect of interview season on combined heating and electricity costs ($p<0.1$). We therefore ran additional sensitivity checks controlling for interview season, and the results are consistent with the models presented here.

[vi] We also explored the reverse relationship—different thresholds of economic poverty leading to energy burdens in a fixed effects logistic regression model. Results are available upon request, and indicate that lagged economic poverty is positively correlated with future energy burden status (controlling for factors described in the Data section).

[vii] Heating subsidies are not included in the main model due to potential double-counting (if respondents track subsidies as reduced expenditure then they are incorporated into the energy burden metric), and a potential spurious correlation due to eligibility criteria. LIHEAP "Crisis" assistance is only available to households at risk of disconnection (i.e. who are behind on their utility bills), and many states use higher income eligibility thresholds and/or provide larger subsidies for crisis assistance. These characteristics would select for households at risk of poverty entry or extension. Historically, LIHEAP participation was strongly predicted by households receiving other forms of social welfare (SSI, e.g.; Higgins and Lutzenhiser 1995).

[viii] State-level average residential prices for electricity in the contiguous U.S. in May 2018 ranged from 9.53 cents/kWh in Louisiana to 21.69 cents/kWh in Massachusetts (U.S. EIA 2018). Rates and rate structures also vary within states, e.g. flat rates, time-of use rates, inclining or declining block rates, flat customer charges vs. volumetric charges, etc.