Finance and Economics Discussion Series

Federal Reserve Board, Washington, D.C.
ISSN 1936-2854 (Print)
ISSN 2767-3898 (Online)

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2025-026

Please cite this paper as:
Aguilar, Octavio M., and Cristina Fuentes-Albero (2025). "Energy Consumption and Inequality in the U.S.: Who are the Energy Burdened?," Finance and Economics Discussion Series 2025-026. Washington: Board of Governors of the Federal Reserve System, https://doi.org/10.17016/FEDS.2025.026.

Energy Consumption and Inequality in the U.S.: Who are the Energy Burdened?*

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April 1, 2025

Abstract

Using a broad definition of energy consumption that includes both residential energy use and gasoline for transport, we identify 20% of households in the PSID as energy burdened (EB) based on a twice-the-median, income-based threshold. Logit analysis shows that being non-white, being single with dependents, receiving public assistance, having no post-secondary education, and being unemployed increase the probability of being EB. We document four key empirical facts: (1) EB/non-EB status is persistent; (2) EB households have significantly higher marginal propensities to consume and marginal propensities to consume energy compared to non-EB households; (3) EB households experience lower expected energy consumption growth despite having higher expected income growth relative to non-EB households; and (4) EB households face more volatile energy consumption and income than non-EB households. Lastly, we show that both consumption inequality and energy consumption inequality have risen more moderately than income inequality over the 1999 to 2021 period. Inequality in residential energy consumption increased until 2009, then declined, whereas inequality in gasoline consumption for transport has risen steadily, reaching a level 50% higher in 2021 than in 1999.

JEL CLASSIFICATION: E21, I32.
KEYWORDS: ENERGY CONSUMPTION, ENERGY BURDEN, INEQUALITY

*We thank Matthias Paustian, Andreas Tischbirek, Javier Ferri, and seminar participants at the Federal Reserve Board, the conference "Macroeconomic Implications of Decarbonization Policies and Actions", the 2024 Southern Economic Association, and the 2024 Workshop of the G7 CCMWG modeling experts for very useful comments and suggestions. The views expressed in this paper are solely the responsibility of the authors and should not be interpreted as reflecting the views of the Board of Governors of the Federal Reserve System or of anyone else associated with the Federal Reserve System. The collection of data used in this study was partly supported by the National Institutes of Health under grant number R01 HD069609 and R01 AG040213, and the National Science Foundation under award numbers SES 1157698 and 1623684.

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1 INTRODUCTION

The study of empirical patterns in consumption and income using micro-data is ubiquitous in the macroeconomic literature.[1] However, less attention has been devoted to the analysis of energy consumption expenditures using micro-data under a macro approach. In this paper, we document four new empirical facts about energy consumption and energy burden (EB) status in the U.S. using the Panel Study of Income Dynamics (PSID). In particular, we show that *(i)* EB status is persistent; *(ii)* EB households have significantly larger marginal propensities to consume for both energy and all goods; *(iii)* EB households have lower expected energy consumption growth despite having higher expected income growth; and *(iv)* EB households face more volatile energy consumption and income.

Since Boardman (1991), the literature on energy consumption and energy poverty has defined household energy consumption as expenditures on electricity, gas, and other fuels for domestic use (hereafter, residential energy).[2] In our PSID sample, U.S. households spend, on average, approximately 6% of their disposable income on residential energy and an additional 5% on energy for transport. Therefore, we argue that energy consumption should include not only the traditional residential energy component but also expenditures on energy for transport.

Figure 1 presents expenditure shares in overall consumption by income decile in the PSID, based on survey waves from 1999 to 2021. As shown by the orange bars, the share of residential energy expenditures in total consumption declines monotonically with income.[3] However, the share of expenditures on energy for transport, shown in lavender, remains relatively stable across income deciles—except for the top decile. This suggests the prevalence and potential significance of gasoline-related energy expenditures in assessing households' energy vulnerability status.[4]

Using the broad definition of energy consumption described above, we classify households as energy burdened (EB) if the share of energy expenditures to disposable income

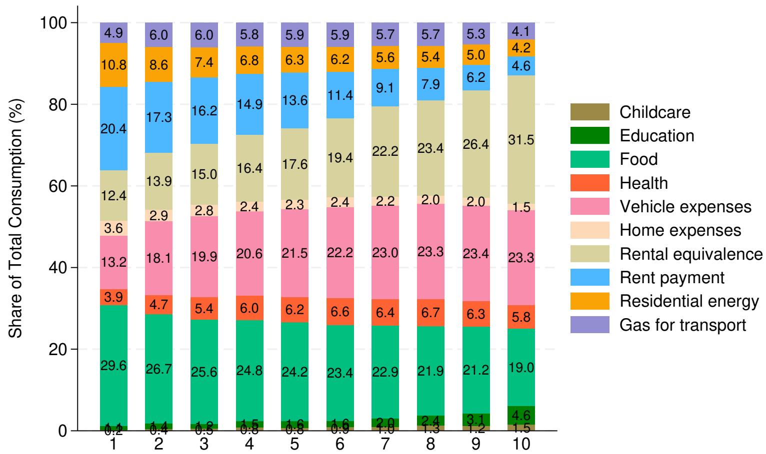
[1] For example, Aguiar, Bils, and Boar (2024), Lewis, Melcangi, and Pilossoph (2024), Attanasio, Hurst, and Pistaferri (2015), Heathcote et al. (2023), and Meyer and Sullivan (2023).

[2] See, for example, Hernandez (2016) or Legendre and Ricci (2015).

[3] Using data from the Residential Energy Consumption Survey (RECS), Linn, Liang, and Qiu (2023) document that the ratio of kilowatt hours (kWh) of electricity consumption per $1,000 of income decreases with income.

[4] Using CEX data from 1999 to 2013, Oni (2024) shows a negative relationship between household expenditure shares on energy, which includes residential and commuting-related expenditures, and income levels.

FIGURE 1: HOUSEHOLDS' EXPENDITURE BY INCOME DECILE, 1999-2021



NOTE: Disposable income deciles are based on the pooled survey data for all waves between 1999 and 2021. Residential refers to expenditures in electricity, gas and other fuel for domestic use and gas for transport refers to expenditures in energy for transport.

exceeds twice the median share in the sample. That is, we use a twice-the-median income-based indicator to conclude that 20% of U.S. households in our sample are classified as EB. The average energy burden—defined as the ratio of energy expenditures to disposable income—is 25% for EB households, compared to only 7% for non-energy-burdened (non-EB) households. Most EB households (81%) are concentrated in the bottom two quintiles of the income distribution.

We characterize EB households using logit regression analysis and find that the probability of being energy burdened is inversely related to household income. Consistent with Wang et al. (2021)'s findings using the Residential Energy Consumption Survey (RECS), we find that, after controlling for socioeconomic characteristics, Black, Asian, and Hispanic households are significantly more likely to be energy burdened relative to White households. Additionally, our analysis suggests that being married, employed, or having post-secondary education reduces the probability of being energy burdened. Conversely, households with children are more likely to be energy burdened. Finally, consistent with Best and Sinha (2021)'s findings for RECS data, we find that receiving government assistance in the form of subsidized housing, food assistance, or heating subsidies is associated with a higher probability of being energy burdened.

In this paper, we put forward four empirical facts about energy consumption and energy-burdened status in the PSID. First, EB status is persistent. Indeed, an EB household has a probability of roughly 50% of being EB in the next survey wave, while a non-EB household has a nearly 90% probability of remaining non-EB across waves. Logit regressions suggest that the probability of remaining EB in two consecutive waves is inversely related to household income. Households with an employed head or post-secondary education are more likely to transition to non-EB status in the following wave. However, homeowners, Black households, and those with a female or unmarried head of household have a higher probability of remaining EB. Second, EB households have significantly larger marginal propensities to consume (MPCs) and marginal propensities to consume energy (MPCEs) than non-EB households. Third, despite experiencing higher income growth, EB households have lower expected energy consumption growth than non-EB households. Finally, EB households exhibit more volatile expected energy consumption and income than non-EB households.

We also examine trends in income, consumption, and energy consumption inequality in our sample. Consistent with Heathcote et al. (2023) and Meyer and Sullivan (2023), we find that the rise in income inequality (24%) is substantially larger than that in consumption inequality (14%). Moreover, the increase in energy consumption inequality closely mirrors that of overall consumption inequality. Notably, inequality in total energy consumption and residential energy consumption rose by nearly 30% on average between 1999 and 2009 but declined by 13% in the following decade. In contrast, inequality in transport energy consumption surged by 46% over the same period.

When comparing inequality trends within EB and within non-EB households using the 90:10 inequality ratio,[5] we find that income inequality increased by 43% between 1999 and 2021 for EB households, whereas the rise for non-EB households was just 26%. Conversely, the growth in consumption inequality for EB households was half that of non-EB households. We also find that residential energy consumption inequality has been declining for EB households throughout the sample period, whereas for non-EB households, this decline began only after 2009. Finally, we identify transport energy consumption as the category with the largest increase in inequality over the sample period, rising by 68% for EB households and 50% for non-EB households. These findings underscore the importance of incorporating transport energy consumption in studies of household energy consumption in the U.S., as focusing solely on residential energy would overlook a substantial component.

The remainder of the paper is structured as follows. Section 2 describes the PSID data,

[5] The 90:10 ratio for income is defined as the ratio of the income needed to rank among the top 10% of households in the distribution (the 90th percentile) to the income at the threshold of the bottom 10% of households (the 10th percentile).

Section 3 discusses the classification of energy-burdened households, Section 4 characterizes EB households, Section 5 puts forward empirical regularities for EB status and energy consumption, Section 6 explores the evolution of inequality, and Section 7 concludes.

2 Data

We use data from the Panel Study of Income Dynamics (PSID), a longitudinal survey of U.S. households. The PSID began in 1968 with a sample of approximately 5,000 households, of which around 3,000 were representative of the U.S. population (the Survey Research Center, SRC, sample or core sample), while about 2,000 were low-income families (the Survey of Economic Opportunity, SEO, sample) (PSID, 2024). The core sample comprised 60% of the original sample, while the SEO sample accounted for the remaining 40%. The original families and their split-offs have been followed continuously, with annual waves until 1996 and biannual waves since 1997. In this paper, we use data from 1999 to 2021. We begin our sample in 1999 for two reasons. First, the PSID underwent a redesign in the late 1990s, introducing a new consumption module that, since 1999, has collected 70% of consumption expenditures, covering categories such as food, housing, transportation, education, and child care. Second, the wealth module has been included in every wave since 1999, providing detailed information on asset holdings.

We exclude households with top-coded data in the following variables: non-housing wealth, mortgage, home value, rental payment, health insurance, any component of our consumption measure, and any component of our income definition. Following Kaplan, Violante, and Weidner (2014), we exclude households with missing information on race, education, or state of residence. We also exclude households with missing or faulty information regarding homeownership status. Following Andrés et al. (2022), we remove households with contradictory information on homeownership—specifically, those reporting not owning a house while also reporting positive net equity. Additionally, we exclude households with after-tax income and/or annual consumption below $\$2,000$, as in Aguiar, Bils, and Boar (2024). Similar to Kaplan, Violante, and Weidner (2014), we exclude households whose income increases by more than 500 percent or decreases by more than 100 percent. We also remove households with consumption below $5 and those reporting zero energy consumption. Finally, we exclude households with extreme average propensities to consume (APCs), keeping only those with APCs less than or equal to 2. After applying these restrictions, our pooled sample contains $58,303$ observations.

In our analysis, in addition to household-level characteristics, we use four key variables: income, consumption, and two definitions of energy consumption. Similar to Fisher et al. (2019), we express all monetary values in constant 2019 dollars. Following Aguiar, Bils, and Boar (2024), we apply family longitudinal weights. Our definition of income corresponds to family disposable income and includes salaries and other compensation, as well as private and government transfers.[6] From this total, we subtract rent payments, property taxes, mortgage interest, and home insurance. We use the NBER TAXSIM (version 35) calculator to compute after-tax income.[7] Similarly to Aguiar, Bils, and Boar (2024), we define consumption expenditures as food at home and food away from home, utilities, gasoline, public transportation, childcare, health expenditures, education, vehicles spending for purchases, repairs, insurance and parking, and spending on shelter, which includes rental payments for renters and, for homeowners, 6% of the respondent's valuation of their home.

We use two definitions for energy consumption: *(i)* residential energy consumption, which includes expenditures in electricity, gas and other fuel for home use;[8] and *(ii)* overall energy consumption, which encompasses residential energy consumption and expenditure in gasoline for transport. In the U.S., households devote 6% of their income, on average, to residential energy expenditures and about 5% to energy for transport expenditures. In addition, according to the American Community Survey and the U.S. Bureau of the Census, in 2020, 85% of U.S. workers commute by private vehicle with 75% of all commuters driving alone in their private car. Only 5% of workers use public transport to commute to work and 3% walked to work.[9] Given the prevalence of private motor vehicles in daily commutes in addition to the geographical and urban/rural planning characteristics of the U.S., we argue that expenditure on gas for transport is a basic energy expenditure

[6] Thus, family income accounts for, for both the household head and other adults in the household: salaries; dividends; rent payments received; workers' compensation; trust fund income; financial support from relatives and non-relatives; child support received; alimony received; Supplemental Security Income (SSI); Temporary Assistance for Needy Families (TANF) and other welfare; pensions/annuities; lump sum payments (e.g., inheritances, itemized deductions); and financial support given to others.

[7] The NBER TAXSIM calculator and background information are available at https://www.nber.org/research/data/taxsim.

[8] Many European-based studies on energy poverty include only utilities (electricity and gas for heating and cooking) in the definition of energy consumption given that the first definition of fuel poverty dates back to Boardman (1991) and included space heating, water heating, lights, appliances and cooking in the definition of spending on energy services.

[9] The data comes from U.S. Bureau of the Census, Journey to Work: 2000, Tables 1 and 2, 1990-2000, March 2004 (www.census.gov/population/www/socdemo/journey.html). and the U.S. Bureau of the Census, 2015-2019 American Community Survey Five-Year Estimates, "Explore Census Data," Beta version. Data also available at U.S. Department of Energy (DOE), Oak Ridge National Lab (2022) Transportation Energy Data Book Edition 40.

for American households. Moreover, given that the size of the share of income devoted to energy for transport is as large as that for residential energy, we argue that these energy expenditures should be taken into account when talking about households' energy consumption.

In the U.S., other surveys provide household-level information on energy consumption, such as the U.S. Energy Information Administration's Residential Energy Consumption Survey (RECS) and the U.S. Census Bureau's Household Pulse Survey. However, these surveys rely on cross-sectional research designs, making them less suitable for tracking households over time and, therefore, assessing the persistence of energy insecurity. Additionally, household income data in these surveys is less granular than in the PSID. While the PSID records actual reported income, RECS and the Household Pulse Survey only categorize income into bins.

3 Energy poverty, insecurity, and vulnerability: Defining energy-burdened households

In the literature, energy poverty is often referred to as fuel poverty, energy insecurity, or energy vulnerability, despite these terms having slightly different meanings or connotations. Moreover, while energy poverty is generally defined as a household's inability to meet its energy needs, its specific meaning varies depending on a country's level of development. In developing economies, energy poverty refers to a lack of access to basic energy services necessary for fundamental needs such as cooking or lighting. In contrast, in developed economies, it refers to the unaffordability of energy services for heating and cooling, in addition to lighting and cooking. In Section 3.1, we review definitions of energy poverty, insecurity, and vulnerability in developed economies and propose the use of the term energy-burdened households. Then, in Section 3.2, we classify households as energy burdened or not energy-burdened using a variety of indicators from the literature. We propose as our baseline indicator a twice-the-median (2M) income-based measure that incorporates a broader definition of energy expenditures, including both residential energy costs and gas for transport. Using this baseline indicator, we classify 20% of U.S. households in our data sample as energy-burdened.

3.1 DEFINITIONS

For developed economies, the concept of energy poverty was put forward by Isherwood and Hancock (1979) in the U.K. following the 1970s energy crisis. They defined "households with high fuel expenditure as those spending more than twice the median (i.e. 12%) on fuel, light, and power". It was Boardman (1991) who introduced the first formal definition of energy poverty: "a home would be energy poor if its expenditure in energy services exceeded 10% of its total income", which was used by the English Housing Condition Survey (EHCS) to measure "affordable warmth" in the 1990s and to define fuel poverty, and hence energy poverty, in the UK Fuel Poverty Strategy of 2001. Indeed, the 10% threshold is ubiquitous in the empirical research as the most common, if not preferred, measure for energy poverty.

In the U.S., however, the term most commonly used is energy insecurity. The U.S. Energy Information Administration (EIA) defines energy insecurity as the inability to adequately meet household energy needs, where household energy needs refer to domestic or residential energy services (Hernandez, 2016). The EIA provides information on energy insecurity in the Residential Energy Consumption Survey (RECS). In the RECS survey, energy insecurity is related to five energy insecurity issues: reducing or forgoing food or medicine to pay energy costs; leaving home at unhealthy temperature; receiving disconnect or delivery stop notice; unable to use heating equipment; and unable to use air-conditioning equipment. Therefore, energy insecurity is a mix of household energy expenditures, the physical conditions of housing units, and energy-related behaviors.[10] The U.S. Census Bureau's Household Pulse Survey definition of energy insecurity includes three conditions: (1) a difficulty paying energy bills, (2) reduced or forewent basic necessities like food and medicine to pay an energy bill, or (3) kept home at an unsafe temperature because of energy cost concerns. In the 2020 RECS survey (the last one available), 27% of households reported facing some type of energy insecurity and around 20% of respondents gave up basic necessities to pay their energy bill; while about 30% of respondents did so in the 2023 U.S. Census Household Pulse Survey.

The term energy vulnerability lacks a clear definition. For example, Legendre and Ricci (2015) define fuel- or energy-vulnerable households as those for whom domestic energy expenditures are the primary factor driving them into poverty—that is, households pushed into poverty due to their domestic energy costs. Thus, energy vulnerability re-

[10] Steele and Bergstrom (2021) estimate and compare alternative empirical approaches to generate an energy insecurity index using data from the 2015 Residential Energy Consumption Survey (RECS). They conclude that, in 2015, between 9 and 22% of U.S. households were energy insecure.

lates to exposure to energy shocks. However, as highlighted by Middlemiss and Gillard (2015), energy vulnerability is also linked to a household's inability to access the energy services necessary for an adequate standard of living. Specifically, they argue that energy vulnerability encompasses both the likelihood of experiencing energy poverty and the capacity to adapt to changes in energy poverty.

Despite the distinctions described above, the terms energy poverty, energy insecurity, and energy vulnerability are often used interchangeably in the literature. In this paper, we propose using the term *energy-burdened households* and define a household as energy burdened if its energy expenditures as a share of disposable income—its energy burden—exceed twice the median share in the sample.

3.2 INDICATORS

In the literature, energy poverty is measured using two main approaches: income-based indicators and expenditure-based indicators. Income-based indicators assess energy expenditures as a share of disposable income—commonly referred to as energy burden—while expenditure-based indicators measure energy expenditures as a share of total consumption expenses, capturing relative energy consumption. Among income-based indicators, the most commonly used are the twice-the-median (2M) indicator, the Minimum Income Standard (MIS) indicator, and the Low Income High Cost (LIHC) indicator. In contrast, expenditure-based indicators primarily rely on variations of the 2M approach. These indicators are typically defined in the literature using residential energy expenditures as the measure of energy consumption. However, as previously noted, the share of disposable income spent on transport-related energy is substantial. Therefore, energy consumption should account not only for utility expenditures but also for gas for transport. Accordingly, as shown in Table 1, we compute the share of energy-burdened households using both residential energy expenditures alone and total energy consumption across all indicators under analysis.

Under 2M income-based indicators, a household is energy burdened if the percentage of disposable income spent on energy consumption to maintain energy services exceeds a given threshold. Therefore, these indicators provide a threshold to classify households as energy burdened. Since Boardman (1991), most of the literature uses a 10% threshold. Indeed, the 10% indicator was the official energy poverty indicator in the UK from 2001 to 2013. We argue that, while, in origin, the 10% threshold coincided with twice-the-median

TABLE 1: SHARE OF ENERGY-BURDENED HOUSEHOLDS (IN %)

	Residential	Overall Energy
Income-based indicators		
2M threshold	23	20
10% threshold (residential)	14	–
20% threshold (overall)	–	10
MIS	10	11
LIHC 1	29	30
LIHC 2	11	10
Expenditure-based indicators		
2M threshold	19	13
10% threshold (within-home)	21	–
20% threshold (overall)	–	15

Note: For the income-based approach, the 2M threshold for residential energy burden is 7.6%, while the 2M threshold for overall energy burden is 15.5%. The share of households that fall below poverty because of energy expenses is 2% for residential energy consumption and 3% for overall energy consumption. For the expenditure-based approach, the 2M threshold for residential energy relative consumption is 11%, while the 2M threshold for overall energy relative consumption is 23%.

energy burden in the data,[11] differences across countries and over time make the 10% inadequate to measure the extent of energy poverty in an economy. We propose to come back to the origins and compute the threshold associated with the 2M indicator using PSID data from 1999 to 2021.

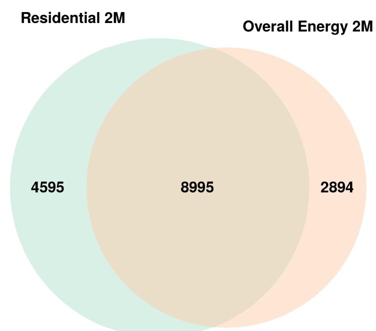
Using pooled data, the 2M threshold for residential energy consumption is 7.6%, while for overall energy consumption is 15.5%. Thus, a 10% approach would underestimate the share of energy-burdened households when using only residential energy and would overestimate the share when considering overall energy consumption. We suggest that when considering the 10% approach with overall energy consumption, we should use a 20% threshold instead of a 10% threshold. As shown in Table 1, while 14% of households are energy-burdened under a 10% threshold using only residential energy expenditures, 23% of households are energy-burdened using the 2M indicator. When considering overall energy expenditures, only 10% of households are energy burdened under the 20%

[11] Boardman (1991) chose this value for the threshold because it was twice the median energy expenditure in the UK in 1988.

threshold, while 20% are classified as being energy burdened under the 2M threshold rule.

Figure 2 illustrates the overlap in our sample between the twice-the-median (2M) indicator based on residential energy consumption and the 2M indicator based on total energy consumption. Of the 13,590 households classified as energy burdened under the residential energy-based 2M indicator, 66% are also classified as energy burdened under the total energy-based 2M indicator. Conversely, of the 11,889 households identified as energy burdened under the total energy-based 2M indicator, 76% are also classified as energy burdened under the residential energy-based 2M indicator.

FIGURE 2: ENERGY BURDEN FOR RESIDENTIAL AND OVERALL ENERGY



NOTE: Author's calculations from the PSID. Figure reports counts.

The Minimum Income Standard (MIS) approach proposed by Moore (2012) defines a household as energy poor if she does not have enough income to pay for energy costs, after covering housing and other needs. This indicator identifies households that would be above the poverty threshold but fall below it because of their energy expenditure. We compute the MIS indicator using the federal poverty thresholds published by the U.S. Department of Health and Human Services. As shown in Table 1, 11% of households in our sample are energy burdened using the MIS approach with overall energy consumption and 10% with residential consumption.

Under the Low Income High Cost (LIHC) approach put forward by Hills (2012), a household is energy poor if her income is below certain poverty threshold and her energy costs are higher than an energy expenditure threshold. For the LIHC 1 measure, the income threshold is 60% of the median equivalent income net of housing and energy costs and the energy threshold as the median equivalent energy expenditure.[12] The share of energy-

[12] Equivalent income is calculated as income over the square root of family size. When considering

burdened households in the U.S. is about 30% for both residential energy expenditures and overall energy consumption.[13] The LIHC 1 indicator has been the official metric for energy poverty in the UK since 2013 and, as indicated by Burlinson, Giulietti, and Battisti (2018), it is gaining traction in European-based studies. The LIHC 2 measure is based on the indicator proposed by Romero, Linares, and López (2018). Under the LIHC 2 measure, a household is energy poor if her energy expenditure exceeds the median energy expenditure and her income net of energy expenditures exceeds 60% of the median household income (not equivalent income) net of the mean energy expenditure. In this case, about 10% of U.S. households are energy burdened both when considering residential energy consumption and when using total energy consumption.

All the measures above look at energy consumption vis-a-vis income. In a study for Canada, Green et al. (2016) suggest, "to identify households as being in energy poverty if energy accounts for at least 10% of their total expenditures". Therefore, we also consider 2M indicators using relative energy consumption as shown in the bottom panel of Table 1. Under a standard 2M approach, 13% of household are energy burdened when using total energy consumption while 19% of households are classified as energy burdened when using residential energy consumption. Following the 10% threshold suggested by Green et al. (2016), the share of energy-burdened households increases to 21% when using residential energy consumption. The share of energy-burdened households increases to 15% when considering total energy consumption and a 20% threshold.

For the remainder of the paper, we use the 2M indicator based on total energy consumption as our baseline measure, as it is our preferred metric for assessing household energy burden in the PSID.

4 WHO ARE THE ENERGY-BURDENED HOUSEHOLDS?

In this section, we first study the defining characteristics of the EB households identified using our baseline indicator, that is, the 2M indicator for total energy consumption. We then assess whether EB households are just traditional hand-to-mouth consumers. Finally, we study the role of these characteristics in increasing the probability of being

only residential energy expenditures, the income threshold is 60% of the median equivalent income net of housing and residential energy costs and the residential energy threshold as the median equivalent energy expenditure. When considering total energy expenditures, the income threshold is 60% of the median equivalent income net of housing and overall energy costs and the overall energy threshold as the median equivalent energy expenditure.

[13] Using the OECD weights to compute equivalent incomes, the share of energy-burdened households using total energy consumption is 31%.

energy-burdened using a multinomial logit approach.

4.1 HOUSEHOLD CHARACTERISTICS

Table 2 reports the share of EB households in each decile of the disposable income distribution. There is a negative relationship between the share of EB households and income. For example, while 67% of households in the first decile of the income distribution are energy burdened, less than 1% of households in the top decile are energy burdened. Additionally, we report the distribution of EB households across income quintiles in Table 3. We conclude that 84% of EB households are concentrated in the first two quintiles of the income distribution.

TABLE 2: SHARE OF ENERGY-BURDENED HOUSEHOLDS IN EACH DECILE (IN%)

Decile	1	2	3	4	5	6	7	8	9	10
Share (%)	67	46	32	22	16	11	6	4	2	0.5

TABLE 3: ENERGY-BURDENED HOUSEHOLDS ACROSS INCOME QUINTILES (IN%)

Quintile	1	2	3	4	5
Share (%)	55	26	13	5	1

In Table 4, we provide the averages for income, consumption, and energy consumption across the two different types of households. Notably, EB households generate an income that amounts to just 37% of non-EB households' income but their total consumption is 76% of non-EB households' consumption. However, energy consumption by EB households is 49% higher that of non-EB households, which is driven by both higher consumption on residential energy as well as gas for transport.

In Table 5 we report the average propensity to consume (APC), defined as consumption-to-income ratios, for both types of households. The APC for energy is also known in the literature as energy burden. Both Table 4 and Table 5 show how aggregate values mask the consumption behavior of EB households. For example, as shown in Table 5, the APC for overall consumption for all households is 0.84, while the same APC for EB households is 1.51. In addition, the average APC for EB households across all measures of energy consumption is nearly triple the amount of all households. The average EB household spends 25% of her income on total energy consumption, 15% of her income in

TABLE 4: SAMPLE STATISTICS: MEANS

	All Households	Energy Burdened	Non-Energy Burdened
Income	\$66,843	\$28,044	\$74,916
Consumption	\$43,571	\$34,405	\$45,478
Energy consumption	\$4,430	\$6,097	\$4,083
Residential consumption	\$2,278	\$3,040	\$2,119
Transport consumption	\$2,152	\$3,057	\$1,964

TABLE 5: AVERAGE PROPENSITY TO CONSUME

	All Households	Energy Burdened	Non-Energy Burdened
Consumption	0.84	1.51	0.70
Energy consumption	0.10	0.25	0.07
Residential consumption	0.05	0.15	0.04
Transport consumption	0.04	0.11	0.03

utilities, and 11% in gas for transport. However, non-EB households spend only about 7% of their income in energy expenditures.

We further our characterization of the differences between EB and non-EB households by looking at their demographic and economic characteristics, as presented in Table 6. Relative to non-EB households, among EB households, there is a higher share of unemployed (10% compared to 5%), renters (46% compared to 41%), dwellings in mobile homes (10% compared to 4%) and government housing (8% compared to 4%). Additionally, a larger share of EB households receive heating subsidies (12% compared to 3%) and participate in welfare programs such as free school lunch or SNAP (35% compared to 13%). Lastly, regarding demographic and geographic characteristics, EB households have a higher share of unmarried head of households (60% compared to 40%), higher share of Black households (50% compared to 29%), and higher share of households located in the South (53% compared to 40%). We use this basic characterization of the demographic, socioeconomic, and geographic characteristics of EB and non-EB households as motivation to estimate whether these factors contribute to being energy burdened in the Section 4.3.

TABLE 6: HOUSEHOLD CHARACTERISTICS (SHARES IN %)

	Energy Burdened	Non-Energy Burdened
Unemployed	10	5
Debt holders		
Mortgage debt	32	41
Non-mortgage debt	48	57
Renters	46	41
Dwellings		
Apartments	18	22
Mobile homes	10	4
Government housing	8	4
Type of heating		
Gas	51	54
Electricity	39	37
Oil	4.80	4.80
Wood	1.30	1.10
Coal	0.10	0.10
Solar	0.00	0.20
Propane	2.40	1.80
Kerosene	0.60	0.00
Other	5.0	4.70
Receive gov't heating subsidy	12	3
Welfare programs (free school lunch or SNAP)	35	13
Married	40	60
Race		
White	44	65
Black	50	29
Asian	1	1
Other	5	5
Region		
Northeast	11	14
Northcentral	24	26
South	53	40
West	12	20

4.2 ARE EB HOUSEHOLDS JUST HAND-TO-MOUTH HOUSEHOLDS?

Since EB households are primarily concentrated in the lowest income quintiles, as shown in Table 3, one might question whether they are simply hand-to-mouth (HTM) consumers. To address this issue, we identify the shares of households who are not HtM (non-HTM), poor HTM households (P-HTM), and wealthy HTM households (W-HTM) in our dataset following Aguiar, Bils, and Boar (2024). In our setup, P-HTM households are defined as households with net worth smaller than two months labor earnings as in Zeldes (1989) and W-HTM as those that are not P-HTM and have negative liquid wealth with absolute value exceeding 16.5% of their annual income.[14]

TABLE 7: HAND-TO-MOUTH STATUS OF EB HOUSEHOLDS

	Energy Burdened	Non-Energy Burdened
P-HTM	32%	27%
W-HTM	37%	24%
Not-HtM	31%	49%

As shown in Table 7, 69% of EB households are classified as HTM, with 32% being P-HTM and 37% W-HTM. This implies that a substantial share—31%—of EB households are not HTM. Among non-EB households, we also observe significant shares of P-HTM (27%) and W-HTM (24%), while 49% are classified as not-HTM. Table 8 presents the distribution of EB and non-EB households across the P-HTM, W-HTM, and not-HTM categories. Our findings indicate that while HTM households are more likely to be EB than non-HTM households, EB households exist across all HTM classifications in non-negligible proportions. Therefore, we argue that EB households represent a distinct and meaningful category within the PSID, warranting further empirical and theoretical investigation.

TABLE 8: EB STATUS OF HTM HOUSEHOLDS

	P-HTM	W-HTM	Not-HTM
Energy-Burdened	23%	28%	14%
Not Energy-Burdened	77%	72%	86%

4.3 REGRESSION ANALYSIS

For our regression analysis, we are interested in how energy burden co-varies across different household characteristics. Following an empirical approach similar to Best and

[14]This criteria for liquid wealth was put forward by Kaplan, Violante, and Weidner (2014). Conversely to Kaplan, Violante, and Weidner (2014), Aguiar, Bils, and Boar (2024) impose that P-HTM and W-HTM are mutually exclusive household types.

Sinha (2021), Mohr (2018), or Romero, Linares, and López (2018), we estimate the following logit model from 1999-2021 using the full sample of households:

$$ln\left(\frac{p}{1-p}\right) = x_i'\beta + \varepsilon_i. \tag{1}$$

In equation 1, the outcome variable is the log of the odds of being energy burdened according to our 2M approach on total energy consumption, and p is the probability of being energy burdened. The vector of explanatory variables, x, includes socioeconomic status, home ownership status, type of dwelling, type of heating used, general demographics, and geographic location.[15]

The results of our regression analysis are shown in Table 9, and are reported as average marginal effects. Reporting the marginal effects allow us to interpret the results as differences in probabilities, which is more informative than an odds ratio. Each column adds a set of covariates. We will discuss the results from the full specification in column 5. First, the estimates provide evidence that the probability of being energy burdened is inversely related to household income. In particular, our results show that being in the bottom two income quintiles is associated with a higher probability of energy burden relative to income quintiles three, four, and five, which suggests that income directly alleviates energy burden.

When examining ownership status, we find that homeowners exhibit a higher probability of being energy burdened compared to renters, and that house size is negatively related to energy burden. Focusing on specific dwelling types, we find that, relative to living in an apartment, one-family houses and mobile homes face a particularly high probability of being energy burdened. In fact, households in mobile homes are 2.2 to 2.4 times more likely to experience energy burden, relative to one- and two-family style houses, respectively. Hence, the nature and size of housing are critical factors in determining energy burden.

In terms of household characteristics, being a race other than White is associated with higher probability of being energy burdened, being the highest for Black households. Corroborating our findings is Wang et al. (2021), who conclude that Black households are more vulnerable than White and Asian households in the 2015 wave of RECS. In our case, we also conclude that Hispanic households have a significantly higher probability of

[15] We also estimate a probit model and a linear probability model (LPM). LPMs are widely used in empirical work, for example, see Tito (2024), and Chen et al. (2017). The LPM serves as a robustness check by including year and state by year fixed effects. We report the results in Appendix Table A1 and conclude our results are robust.

TABLE 9: HOW ENERGY BURDEN COVARIES ACROSS DIFFERENT HOUSEHOLD PROFILES

Variables	(1)	(2)	(3)	(4)	(5)
Socioeconomic					
Bottom two income quintiles	0.128***	0.126***	0.111***	0.098***	0.097***
Ownership status					
Homeowner		−0.029***	0.005	0.016***	0.018***
House size 6+		−0.019***	−0.015***	−0.010***	−0.013***
Type of dwelling					
One family house		0.087***	0.093***	0.088***	0.089***
Two family house		0.079***	0.075***	0.065***	0.065***
Mobile home		0.191***	0.185***	0.142***	0.143***
Rowhome		0.005	0.003	0.008	0.006
Heating					
Gas		−0.001	0.005	0.011**	0.010**
Oil		0.021***	0.056***	0.059***	0.057***
Other (propane, wood, kerosene)		0.037***	0.079***	0.071***	0.066***
Household characteristics					
Race					
Black			0.115***	0.073***	0.074***
Asian			0.004	0.024	0.029*
Other			0.035***	0.031***	0.044***
Hispanic			0.042***	0.047***	0.038***
Married			−0.033***	−0.044***	−0.045***
Female			0.027***	0.015**	0.015**
Kids			0.025***	0.018***	0.019***
Head 65+			0.014***	−0.050***	−0.041***
Other socioeconomic					
Employed				−0.072***	−0.065***
Postsecondary education				−0.068***	−0.069***
Subsidized housing				0.029***	0.029***
Heating subsidy				0.133***	0.123***
Behind on mortgage				0.139***	0.109***
Geographic location					
Northeast				−0.039***	−0.038***
Northcentral				−0.029***	−0.028***
West				−0.067***	−0.067***
Year dummies?	N	N	N	N	Y
N	57,248	57,248	57,248	57,248	57,248
Pseudo R^2	0.084	0.098	0.124	0.155	0.172

NOTE: Asterisks indicate the level of significance of the parameters, * $p < .10$; ** $p < .05$; and *** $p < .01$.

being energy burdened than non-Hispanic households. Additionally, we find that head of households over the age of sixty-five have a lower probability of being energy burdened, while Female head of households and having children is associated with a higher probability of energy burden.

We find that the head of household being married, employed, and having post-secondary education reduce the probability of being energy burdened. Interestingly, households that receive government-subsidized housing and heating subsidies exhibit a higher probability of energy burden. This relationship is also found by Best and Sinha (2021), who use RECS data and focus on residential energy consumption to conclude that the reception of assistance is positively correlated with fuel poverty. Lastly, geographic location plays a role as well; compared to the South, all other regions face lower probabilities of being energy burdened.

In summary, households with low incomes and low levels of education, particularly those living in single-family or mobile homes in the South, and those with children, are the most vulnerable to being energy burdened. As shown in Appendix Table A1 our results are robust to alternative models, such as LPM and Probit. Moreover, as shown in Appendix Table A2, our logit results are robust when we re-estimate equation 1 on a sample excluding households identified as hand-to-mouth by either measure. This confirms that our findings are not confounded by hand-to-mouth status, indicating that our results are explained solely by EB status.

5 ENERGY CONSUMPTION: EMPIRICAL FACTS

While there is a vast literature documenting empirical facts on consumption and income using U.S. micro-data, the study of empirical regularities of energy consumption is in its infancy. In this section, we put forward four empirical facts for energy consumption and energy-burdened status in the PSID: *(i)* households tend to remain energy burdened over time; *(ii)* EB households have significantly larger marginal propensities to consume energy; *(iii)* EB households have lower energy consumption growth than non-EB households despite having higher income growth; and *(iv)* EB households have more volatile energy consumption and income than non-EB households.

FACT 1: EB/NON-EB STATUS IS PERSISTENT

To study the persistence of the EB status, we compute two-year transition rates between EB status in the PSID using the pooled sample and report them in Table 10. Transition probabilities are computed considering households that were included in two consecutive waves, which means that, for example, some households in our 1999 sample are dropped when computing the transition probabilities because they are not included in the 2001

TABLE 10: TRANSITION RATES

	Energy Burdened$_{t+2}$	Non-Energy Burdened$_{t+2}$
A. ***Total Energy***		
Energy Burdened$_t$	0.49	0.51
Non-Energy Burdened$_t$	0.12	0.88
B. ***Residential Energy***		
Energy Burdened$_t$	0.59	0.41
Non-Energy Burdened$_t$	0.11	0.89
C. ***Gas for Transport***		
Energy Burdened$_t$	0.48	0.52
Non-Energy Burdened$_t$	0.17	0.83

NOTE: We use a 2M approach to classify households as EB for each type of energy consumption.

wave. As shown in Panel A of Table 10, if a household is EB in year t using the 2M approach for total energy consumption, the probability of remaining EB in year $t+2$ is 49%. If a household is non-EB in year t, the probability of becoming energy burdened in year $t+2$ is only 12%, that is, the probability of remaining non-EB is 88%. Therefore, we argue that EB/non-EB status is persistent across survey waves. In Panel B and Panel C of Table 10, we report the transition rates when EB status is determined using a 2M approach for residential energy consumption and gas for transport, respectively. The probability of remaining EB when using residential energy consumption is almost 60%, while it remains around 50% when using gas for transport. Notably, the persistence of being non-energy burdened is around 85% irrespective of the definition of energy consumption.

Determinants of persistence in EB status: Next, we study which household characteristics are associated with persistent EB status by estimating a logit model similar to equation 1. Specifically, the dependent variable is the log of the odds of being energy burdened—by total energy, residential energy, or gas for transport—in two consecutive survey waves (e.g., 1999 and 2001).[16] In particular, p is the probability of being EB in two consecutive periods and $(1-p)$ is the probability of being EB in the first wave and

[16]In some cases, a household may appear in both categories. For example, if a household is energy burdened in 1999 and 2001 but not in 2003, it will be counted as 1 for the 1999 to 2001 period and as 0 for the 2001 to 2003 period.

non-EB in the following one. The vector of explanatory variables includes a set of socioeconomic, demographic, and geographic characteristics.

TABLE 11: CHARACTERISTICS OF PERSISTENT EB STATUS

Variables	Total Energy	Residential	Transport
Socioeconomic			
Bottom two income quintiles	0.034***	0.022***	0.032***
Income growth	−0.005	−0.011	−0.011
Energy consumption decline	0.041**	0.015	0.023
Ownership status			
Homeowner	0.097***	0.085***	0.036***
Household characteristics			
Race			
Black	0.054***	0.096***	−0.016
Asian	0.035	0.120*	−0.088
Other	0.046	0.027	0.046*
Hispanic	−0.009	0.037	0.030
Married	−0.065***	−0.057***	−0.035**
Female	0.054***	0.081***	−0.004
Kids	−0.014	−0.033***	0.005
Head 65+	−0.022	0.003	−0.064***
Other socioeconomic			
Employed	−0.079***	−0.104***	−0.032
Postsecondary education	−0.094***	−0.115***	−0.061***
Subsidized housing	0.019	0.034	0.014
Heating subsidy	0.075***	0.099***	0.012
Behind on mortgage	−0.052	−0.053	0.022
Geographic location			
Northeast	−0.024	0.001	−0.035*
Northcentral	−0.010	−0.026*	−0.026*
West	−0.092***	−0.115***	−0.045***
Year dummies?	✓	✓	✓
N	6,610	7,479	8,621
Pseudo R^2	0.060	0.086	0.041

NOTE: The dependent variable is equal to 1 if the household is energy burdened—by total energy, residential energy, or gas for transport—in two consecutive periods. The dependent variable is equal to zero if the household transitions from energy burden in period one to not-energy burdened in period two. Asterisks indicate the level of significance of the parameters, * $p < .10$; ** $p < .05$; and *** $p < .01$.

Table 11 reports the results across three categories of EB status: total energy, residential energy, and transport energy. As before, the results are presented as average marginal effects, allowing us to interpret them as differences in probabilities. Across all specifications, households in the bottom two income quintiles are significantly more likely to experience persistence in EB status; that is, the probability of remaining EB is inversely related to household income. Interestingly, income growth does not have a significant effect on EB status persistence. In other words, an increase in household income between waves does not significantly alter the likelihood of remaining EB in the second wave. Similarly, declines in residential energy consumption or gas for transport between waves do not significantly affect a household's EB status persistence, as shown in the last two columns of Table 11. However, when classifying households as EB based on total energy consumption, a decline in total energy consumption is positively associated with persistent EB status.

Homeownership increases the probability of EB persistence across all types of energy consumption, with a stronger effect for residential energy than for gas for transport. This pattern suggests that homeowners face challenges in adjusting their residential energy use, likely due to inefficient home infrastructure and higher maintenance costs, which contribute to persistent EB status. Demographically, relative to white households, Black households are more likely to experience persistence in total and residential EB status. Female-headed households also exhibit a higher probability of remaining EB for total and residential energy consumption, whereas married households, households with children, and those with an elderly head (65+) are less likely to experience persistence in EB status.

The strongest factors mitigating EB status persistence are employment and education. Being employed significantly reduces the probability of remaining EB in both total and residential energy, while postsecondary education further decreases the risk across all categories. Finally, geographic differences show that, relative to the South, living in the West consistently reduces the probability of persistent EB status. These findings suggest that persistent energy burden status is shaped by a combination of economic, demographic, and geographic factors, with disparities linked to homeownership, location in the income distribution, and race.

FACT 2: EB HOUSEHOLDS HAVE SIGNIFICANTLY LARGER MPC AND MPCEs

The marginal propensity to consume (MPC) out of transitory income shocks is defined as the fraction of a small, unanticipated, one-time increase in disposable income that a household spends within a given time period. In this paper, we introduce the concept of the marginal propensity to consume energy (MPCE), which we define similarly as the fraction of a small, unanticipated, one-time increase in disposable income that a household spends on energy goods and services. We exploit the panel dimension of the PSID data to estimate MPCs and MPCEs for EB and non-EB households in our dataset.

Following the literature (see, for example, Kaplan, Violante, and Weidner, 2014, Auclert, 2019, and Commault, 2022), we use a semi-structural approach to estimate MPCs and MPCEs based on Blundell, Pistaferri, and Preston (2008). In the first step, we regress the log of the measure of consumption of interest (all goods, total energy, residential, or transport) and the log of disposable income on observable households' characteristics and year dummies. Following Commault (2022), these households' characteristics include year of birth, family size, number of children, existence of outside dependent children, education, race, employment status, presence of an additional income recipient that is not the head of the household or spouse, and region. In these regressions, we also include interaction terms between year dummies and education, race, employment status, and region. We then compute the first-difference of the residuals of log consumption and log income denoted by Δc_{it} and Δy_{it}, respectively. Following Auclert (2019), we estimate the pass-through coefficient of log income on log consumption, $\psi_i = \frac{\text{cov}(\Delta c_{it}, \Delta y_{i,t+2})}{\text{cov}(\Delta y_{it}, \Delta y_{i,t+2})}$. Specifically, the Blundell, Pistaferri, and Preston (2008) estimator is implemented by an instrumental variable regression of Δc_{it} on Δy_{it} using $\Delta y_{i,t+2}$ as an instrument.[17] We then recover the estimates of the MPC by multiplying the estimated pass-through coefficient, ψ_i, by the corresponding mean consumption-income ratio (i.e., the average propensity to consume).

In Table 12, we report the estimated pass-through coefficients of transitory income shocks to the various consumption measures for EB and non-EB households. All estimated pass-through coefficients are statistically significant, with those for EB households being larger than those for non-EB households. Consequently, the implied MPCs and MPCEs are substantially higher for EB households, indicating that they are more responsive to temporary, unexpected changes in income than non-EB households.[18] Table A3 in the Appendix confirms that these results are robust to alternative classifications of EB and non-EB households. Recent contributions to the literature, such as Commault (2022) and Crawley (2020), have revisited the estimation procedure of Blundell, Pistaferri, and Preston (2008), demonstrating that the MPC estimates based on Blundell, Pistaferri, and Preston (2008) serve as a lower bound for MPCs. Therefore, we argue that our estimates for MPCs and MPCEs, reported in Table 12, may be at the lower end of the possible range. However, the magnitude of our MPC estimates aligns with recent estimates using the

[17] The PSID survey is biannual although both income and consumption are reported at annual frequency.

[18] In Appendix Figure A.3, we plot the MPC for our total consumption measure by year. Due to the small sample size in each year, the estimates for EB households are quite volatile, ranging from 0.16 to 0.49. As such, we find it more appropriate to estimate MPCs using a pooled sample approach.

TABLE 12: MARGINAL PROPENSITIES. 2M APPROACH

	Total Cons.	Total Energy	Residential	Transport
Panel A: Energy-Burdened Households				
ψ_i	0.161***	0.324***	0.130***	0.313***
	(0.027)	(0.039)	(0.042)	(0.056)
MPC	0.243	0.082	0.020	0.038
Panel B: Non-Burdened Households				
ψ_i	0.131***	0.177***	0.080**	0.154***
	(0.024)	(0.031)	(0.032)	(0.044)
MPC	0.092	0.012	0.003	0.005

NOTE: ψ_i stands for the pass-through coefficient or short-run elasticity of consumption with respect to transitory income shocks and MPC refers to marginal propensity to consume. Standard errors are clustered at the household level and are reported in parenthesis, * $p < .10$; ** $p < .05$; and *** $p < .01$.

PSID by Cho, Morley, and Singh (2024).[19]

FACT 3: EB HOUSEHOLDS HAVE LOWER ENERGY CONSUMPTION GROWTH THAN NON-EB HOUSEHOLDS DESPITE HAVING HIGHER INCOME GROWTH

Table 13 reports the average growth rates of income, consumption, energy consumption, and its components in the sample. The entries in Table 13 are computed as follows: we calculate the growth rate between wave t and wave $t + 2$ for households classified as EB (non-EB) in wave t, divide it by 2 to annualize the rate, and then take the average across EB (non-EB) households.[20] The average income growth for EB households in the sample is substantially higher than for non-EB households. However, while the average growth rates of consumption, energy consumption, and its components for EB households are negative, these rates are positive for non-EB households.

[19] Fisher et al. (2019) estimate MPCs using an Euler equation approach with PSID data from 1999-2013, finding an estimate of 8%.

[20] Table A4 in Appendix B.1 reports the average growth rates for each wave, where, for example, 2001

TABLE 13: AVERAGE ANNUAL GROWTH RATE (IN %) CONDITIONAL ON EB STATUS IN THE FIRST WAVE OF THE GROWTH RATE

	Burdened	Non-Burdened
Income	11.33	-0.83
Consumption	-1.41	1.23
Energy consumption	-9.47	2.53
Residential consumption	-5.87	2.11
Transport consumption	-12.07	2.51

Note: Growth rates are defined as the log-difference between the variable of interest in wave $t+2$ and in wave t, divided by two to annualize the growth rate.

We further explore these differences in growth rates between EB and non-EB households using consumption and income growth regressions. Specifically, we examine whether being energy burdened predicts consumption and income growth, thereby characterizing the role of EB status in these dynamics. To do so, we propose the following consumption (income) growth equation, which closely follows the specification introduced by Aguiar, Bils, and Boar (2024) in their study on the role of hand-to-mouth status in aggregate consumption growth:

$$\Delta \ln x^i_{j,t+2} = \beta_i EB_{j,t} + \phi_i' D_t + \theta_i' X_{j,t} + \varepsilon^i_{j,t+2}, \tag{2}$$

Here, i represents income, overall consumption, total energy consumption, residential energy consumption, and gas for transport energy consumption. The growth rate of variable x is defined as the log-difference between its level in wave $t+2$ and wave t, divided by two to annualize the growth rate. In equation 2, $\text{EB}_{j,t}$ equals 1 if household j is energy burdened in wave t, D_t is a vector of year dummies, and $X_{j,t}$ is a vector of household characteristics. The household characteristics include a quadratic term for age and dummies for changes in marital status and family size. We estimate the growth regressions both with and without household fixed effects.

Panel A in Table 14 reports the results for the growth regressions. For each variable, the first column reports the β_i coefficient in the regression without household fixed effects and the second column reports the estimates for the regression in which we control for household fixed effects. In our case, regardless of whether we control or not for household fixed effects, the sign of the coefficients is the same for each variable while the magnitude is larger when we control for household fixed effects. Our regression results allow us to conclude that EB households have a significantly higher rate of income growth than non-EB households,

refers to the annual growth rate between wave 1999 and wave 2001.

TABLE 14: Growth and Volatility Regressions for Energy Burdened Households

	Income		Consumption		Energy Cons		Residential		Transport	
Regressor	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
A. ***Growth***										
Energy-Burdened	0.128***	0.231***	−0.026***	−0.034***	−0.109***	−0.187***	−0.074***	−0.123***	−0.127***	−0.215***
	(0.007)	(0.010)	(0.004)	(0.008)	(0.005)	(0.009)	(0.006)	(0.011)	(0.008)	(0.014)
Fixed Effects?	No	✓	No	✓	No	✓	No	✓	No	✓
R^2	0.06	0.27	0.02	0.18	0.10	0.25	0.03	0.19	0.08	0.22
B. ***Volatility***										
Energy-Burdened	0.046***	0.024***	−0.001	0.002	0.012***	0.011***	0.021***	0.004***	0.013***	0.010***
	(0.005)	(0.006)	(0.003)	(0.004)	(0.004)	(0.005)	(0.005)	(0.006)	(0.006)	(0.007)
Fixed Effects?	No	✓	No	✓	No	✓	No	✓	No	✓
R^2	0.03	0.45	0.02	0.41	0.01	0.42	0.02	0.49	0.01	0.43

NOTE: Standard errors are clustered at the household level. Asterisks indicate the level of significance of the parameters, * $p < .10$; ** $p < .05$; and *** $p < .01$. The sample size is 17,740.

while EB households face a significantly lower rate of consumption growth than non-EB households for all categories under study.

FACT 4: EB HOUSEHOLDS HAVE MORE VOLATILE ENERGY CONSUMPTION AND INCOME THAN NON-EB HOUSEHOLDS

We also follow Aguiar, Bils, and Boar (2024) in specifying the regression for the volatility of consumption and income growth as follows:

$$\left|\Delta \ln \left(x^i_{j,t+2}\right)_{vol}\right| = \gamma_i EB_{j,t} + \omega_i' D_t + \psi_i' X_{j,t} + \varepsilon^i_{j,t+2}, \tag{3}$$

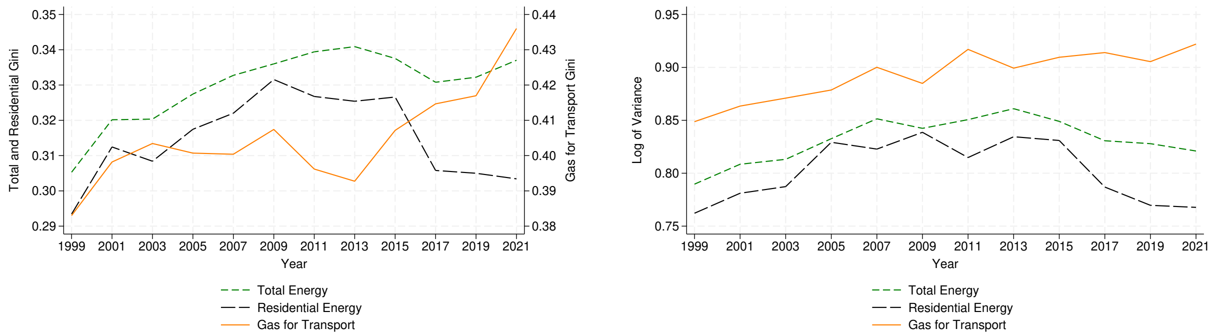
where the volatility measure, $\left|\Delta \ln \left(x^i_{j,t+2}\right)_{vol}\right|$, is defined as the absolute value of the growth rate of variable x minus the growth predicted by the regressions in equation 2.

The results of these volatility regressions are reported in Panel B of Table 14. When comparing the estimates with and without fixed effects, we find that the estimated coefficients are smaller when controlling for household fixed effects. EB households experience greater volatility in future income and energy consumption (and its components) growth than non-EB households. However, the coefficient for total consumption growth volatility is not significantly different from zero. Thus, we conclude that EB households do not face greater volatility in future total consumption growth compared to non-EB households.

6 TRENDS IN INEQUALITY: INCOME, CONSUMPTION, AND ENERGY CONSUMPTION

The study of income and consumption inequality trends has been a central focus in the literature. While there is broad consensus on the rise in income inequality over the past several decades, the trajectory of consumption inequality remains debated. On one side, Aguiar and Bils (2015) and Attanasio, Hurst, and Pistaferri (2015) find that consumption inequality has closely tracked income inequality since the 1980s. On the other, Krueger and Perri (2006), Heathcote et al. (2023), and Meyer and Sullivan (2023) document a more moderate increase in consumption inequality relative to income dispersion since the 1960s. In this paper, we extend this discussion by not only documenting trends in income and consumption inequality in our dataset but also examining the evolution of inequality in energy consumption and its components. To begin, in Figure 3, we present the Gini coefficient and the variance of the log of energy consumption and its components.

FIGURE 3: ENERGY INEQUALITY OVER TIME, 1999-2021



A. Gini

B. Log of Variance

As shown in Figure 3, while both the Gini and variance for transport energy consumption exhibit an upward trend, residential and total energy consumption inequality increased until 2009 before declining. Although the Gini coefficient and the variance of logs are widely used in the literature, they are not without criticism. As noted by Attanasio, Hurst, and Pistaferri (2015) and Heathcote et al. (2023), these measures capture dispersion across the entire population, potentially masking divergent trends across different segments of the distribution. Additionally, self-reported survey data often suffer from measurement issues, particularly at the lower end of the income distribution and the upper end of the consumption distribution.

To mitigate these concerns, Meyer and Sullivan (2023) advocate for using percentile ratios, which are less sensitive to measurement errors in the extreme tails of the distribution when analyzing inequality patterns. In particular, we use the 90:10, 50:10, and 90:50 ratios where the 90:10 ratio describes inequality between the top and the bottom of the distribution, the 50:10 ratio describes inequality between the middle and the bottom of the distribution and the 90:50 ratio describes inequality between the top and the middle of the distribution.

Table 15 presents income, consumption, and energy consumption inequality for all households between 1999 and 2021. As shown in the first column, income dispersion, measured by the 90:10 ratio, was substantially higher in 1999 than consumption and energy consumption dispersion. While income inequality remained relatively stable between 1999 and 2009, it rose significantly after the Great Recession, increasing by approximately 24% between 1999 and 2021. In contrast, consumption inequality grew by about 14% over the same period, with most of the increase occurring between 1999 and 2009. Thus, our re-

TABLE 15: CHANGES IN INEQUALITY ACROSS ALL HOUSEHOLDS (%)

		Percentage Changes		
	Initial Level	1999-2009	2009-2021	1999-2021
90:10 ratio				
Income	8.29	-0.56	24.38	23.68
Consumption	4.69	8.18	4.94	13.53
Energy	4.53	29.04	-10.81	15.09
Residential	4.00	26.92	-15.96	6.67
Transport	5.83	2.86	45.83	50.00
50:10 ratio				
Income	3.08	0.29	13.72	14.06
Consumption	2.23	3.36	2.55	6.00
Energy	2.40	20.83	-13.64	4.35
Residential	2.20	13.29	-11.73	0.00
Transport	2.50	-4.00	25.00	20.00
90:50 ratio				
Income	2.69	-0.85	9.37	8.44
Consumption	2.10	4.66	2.33	7.11
Energy	1.87	6.80	3.28	10.29
Residential	1.82	12.04	-4.79	6.67
Transport	2.33	7.14	16.67	25.00

sults indicate that consumption inequality rose less than income inequality during this period.[21]

The surge in inequality in the lower half of the income distribution, as reflected in the 50:10 ratio, while smaller than for the overall distribution, suggests that households at the bottom have lost ground relative to the median, particularly since 2009. Meanwhile, the gap between the median and the lower end of the consumption distribution has steadily widened at a rate of 3% per decade, though the overall increase remains less than half of the rise in income inequality. In the upper half of the income distribution (measured by the 90:50 ratio), income and consumption inequality have grown at similar rates. Notably, the increase in income inequality in the lower half of the distribution is nearly 70% larger than in the upper half, whereas the rise in consumption inequality in the lower half is about 20% smaller than in the upper half.

We now turn to the evolution of inequality in energy consumption and its components.

[21] Using income data from the Current Population Survey and consumption data from the Consumer Expenditure Interview, Meyer and Sullivan (2023) also find that the rise in income inequality, measured by the 90:10 ratio, outpaced the rise in consumption inequality. They report a 25% increase in income inequality since the 1960s, compared to a 9.5% rise in consumption inequality.

Based on the 90:10 ratio reported in the first column of Table 15, we conclude that inequality in transport energy consumption exceeds that of residential and total energy consumption but remains below the level of income inequality.

TABLE 16: CHANGES IN INEQUALITY MEASURED BY 90:10 RATIO(%)

		Percentage Changes		
	Initial Level	1999-2009	2009-2021	1999-2021
EB households				
Income	6.34	9.01	31.35	43.18
Consumption	4.49	9.04	-1.83	7.05
Energy	4.09	1.64	11.23	13.06
Residential	4.50	-2.22	-11.36	-13.33
Transport	8.33	8.00	55.56	68.00
Non-EB households				
Income	6.44	-2.22	28.67	25.82
Consumption	4.55	9.97	5.07	15.55
Energy	4.55	17.97	-1.75	15.90
Residential	4.00	25.00	-15.07	6.16
Transport	5.00	33.33	12.50	50.00

Residential and total energy consumption inequality fluctuated over the sample period: between 1999 and 2009, inequality rose sharply by about 28%, only to decline by an average of 14% over the following decade. As a result, the overall increase in residential energy consumption inequality over the full sample is modest at 7%, while the rise in total energy consumption inequality closely mirrors that of overall consumption. The 50:10 ratio suggests that since 2009, households in the lower part of the distribution have lost less ground relative to the median in terms of residential and total energy consumption. Moreover, the decline in residential energy consumption inequality since 2009 has been present at both ends of the distribution.

In contrast, the trajectory of transport energy consumption inequality is markedly different. While it remained relatively stable during the first decade of our sample, it surged by 46% between 1999 and 2021—nearly double the increase in income inequality over the same period. Overall, transport energy consumption inequality increased by 50%. Examining different segments of the income distribution, we find that the rise in transport energy inequality is similar at both the top and bottom.

Next, we conduct a similar analysis comparing EB and non-EB households. Figure A.1 in Appendix A, plots the distribution of income and consumption for EB and non-EB households from 1999 through 2021. As shown in Appendix A Figure A.1, the income and consumption distributions for EB households has shifted downward and to the right over time, whereas those for non-EB households have remained relatively stable. Likewise, Figure A.2 in Appendix A, illustrates that the distributions of total energy consumption and its components have shifted to the right for EB households.

TABLE 17: ENERGY-BURDENED HOUSEHOLDS: CHANGES IN INEQUALITY: 1999-2021 (%)

		PERCENTAGE CHANGES		
	Initial Level	1999-2009	2009-2021	1999-2021
90:10 ratio				
Income	6.34	9.01	31.35	43.18
Consumption	4.49	9.04	-1.83	7.05
Energy	4.09	1.64	11.23	13.06
Residential	4.50	-2.22	-11.36	-13.33
Transport	8.33	8.00	55.56	68.00
50:10 ratio				
Income	2.64	8.38	18.81	28.77
Consumption	2.11	4.67	14.74	20.11
Energy	2.18	-7.13	3.64	-3.75
Residential	2.18	1.15	-9.09	-8.05
Transport	3.33	3.20	16.28	20.00
90:50 ratio				
Income	2.40	0.58	10.55	11.19
Consumption	2.13	4.17	-14.44	-10.87
Energy	1.88	9.44	7.33	17.46
Residential	2.07	-3.33	-2.50	-5.75
Transport	2.50	4.65	33.78	40.00

Table 16 reports 90:10 ratios for EB and non-EB households. As in the overall sample, income inequality has risen more than overall consumption and total energy consumption inequality for both EB and non-EB households. However, the increase in income inequality is 65% larger for EB households than for non-EB households (43% vs. 26%), while the rise in consumption inequality for EB households is about half that of non-EB households (7% vs. 16%). Although total energy consumption inequality has risen similarly for both groups, the timing differs: for non-EB households, the increase occurred primarily between 1999 and 2009, whereas for EB households, it took place between 2009 and 2021.

Residential energy consumption inequality has declined for EB households throughout the whole the sample period, falling by 13% from 1999 to 2021. In contrast, for non-EB households, it increased by 25% in the first decade before declining by 15% in the latter part of the sample. Consistent with our previous findings, inequality in gas for transport consumption has steadily increased for both groups. Over the entire sample period, gas for transport consumption inequality rose by 68% for EB households and 50% for non-EB households, significantly outpacing the increase in income inequality for both groups.

Lastly, in Table 17, we examine the evolution of inequality among EB households by reporting the 50:10 and 90:50 ratios. First, income inequality, measured by the 90:10 ratio, increased by 43% between 1999 and 2021, with the largest increase occurring between 2009 and 2021 (31.35%).

Notably, the rise in income inequality was more modest in the earlier period (1999-2009: 9.01%), highlighting an acceleration in the past decade. Comparing the 50:10 and 90:50 ratios, we conclude that income inequality mostly increased in the bottom part of the EB distribution, as the 50:10 ratio grew by 28.77%, compared to an 11.19% rise in the 90:50 ratio. This suggests that income inequality widened more between lower-and middle-income EB households than between middle- and higher-income EB households. Consumption inequality, however, exhibited a different pattern. The overall increase in the 90:10 ratio was relatively small (7.05%), reflecting offsetting trends: while inequality in the bottom half of the distribution increased significantly (50:10: +20.11%), it declined by a similar magnitude in the upper half (90:50: -10.87%). This pattern suggests that while lower-income EB households saw greater inequality in consumption, inequality among higher-income EB households narrowed, suggesting a reduction in consumption gaps at the top of the distribution. In terms of the components of energy consumption, residential energy inequality declined over the sample, particularly in the upper half of the distribution (90:50: -5.75%). In contrast, transport energy inequality increased dramatically at both ends of the distribution, with the 90:10 ratio rising by 68% and the 50:10 ratio by 20%.

7 CONCLUDING REMARKS

Using U.S. micro-data from the PSID, we show that energy burden is persistent, disproportionately affects lower-income households, and is associated with higher marginal propensities to consume and marginal propensities to consume energy. Our study also shows that energy-burdened households face more volatile energy consumption and income growth than non-burdened households, despite experiencing higher income growth on average. Importantly, we broaden the definition of household energy consumption to include gasoline for transport, demonstrating that traditional measures of energy burden, which focus solely on residential energy expenditures, fall short in identifying the overall scope of energy burden in the household sector. By examining the evolution of inequality in income, consumption, and energy expenditures, we find that income inequality has increased at a faster rate than energy consumption inequality, with the burden of rising inequality being more pronounced among energy-burdened households. The empirical facts documented in this paper provide a guidance to discipline the calibration of theoretical macroeconomic models with some degree of household heterogeneity regarding energy burden and energy consumption.

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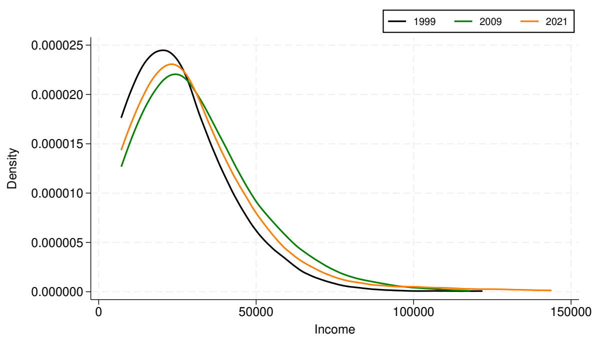
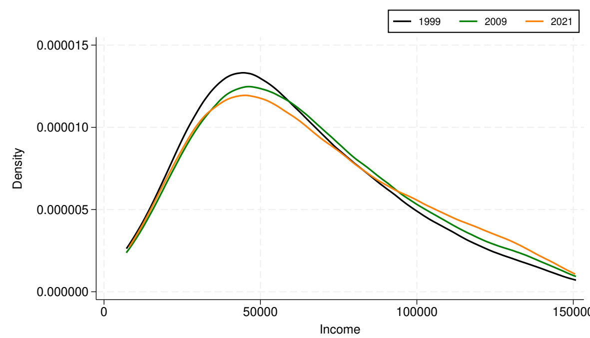
Online Appendix

A Appendix: Figures

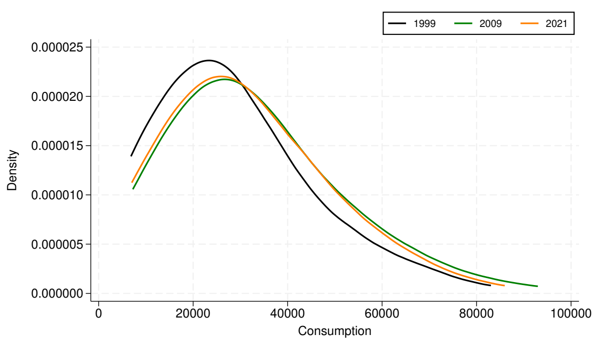
FIGURE A.1: DISTRIBUTION OF INCOME AND CONSUMPTION



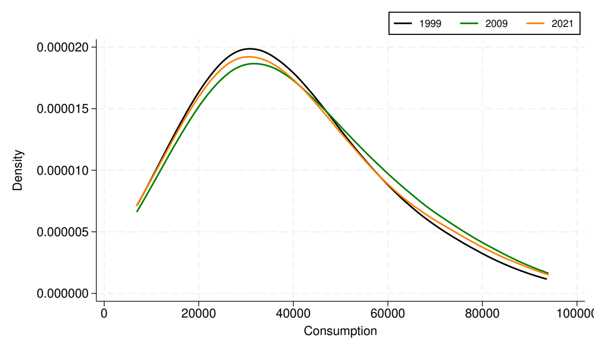
A. Income: EB Households



B. Income: Non-EB Households

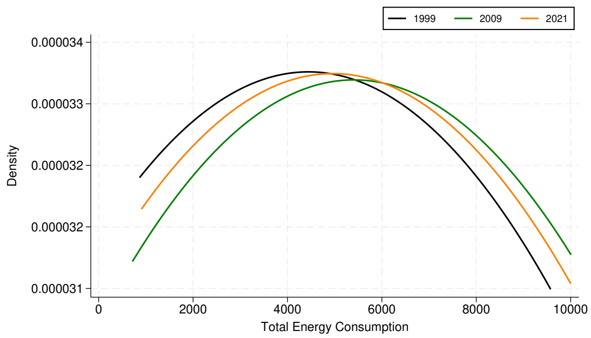


C. Consumption: EB Households

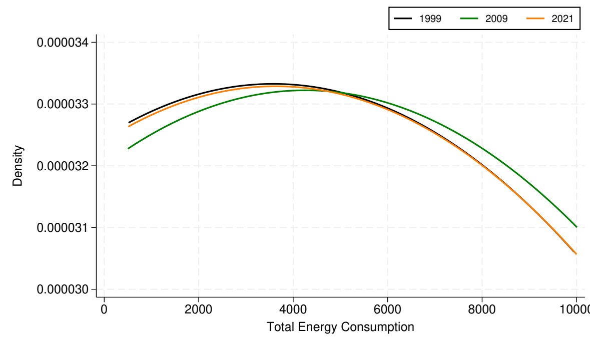


D. Consumption: Non-EB Households

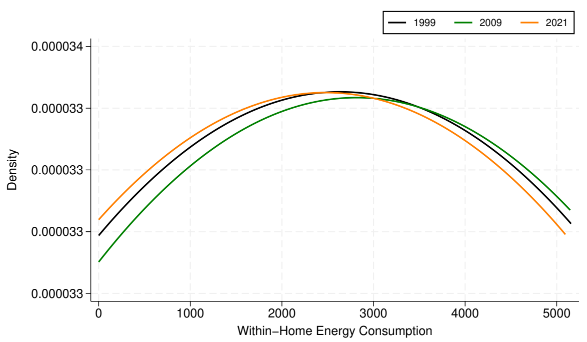
Figure A.2: Distribution of the Components of Energy Consumption



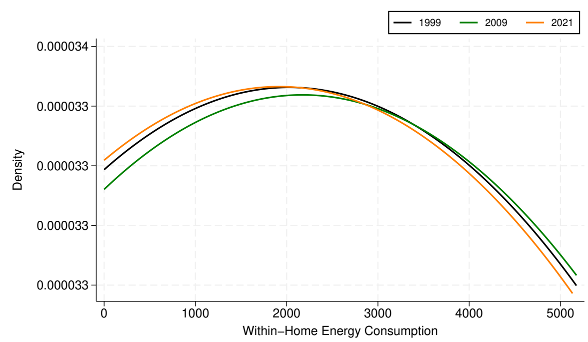
A. Total Energy: EB Households



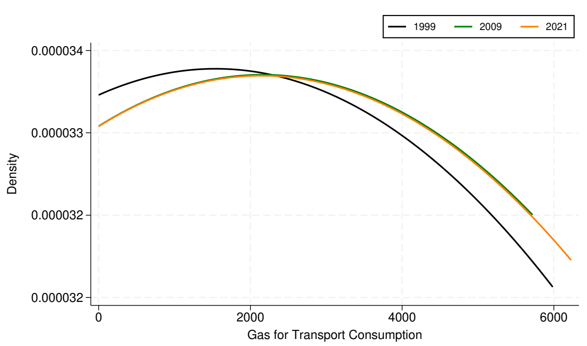
B. Total Energy: Non-EB Households



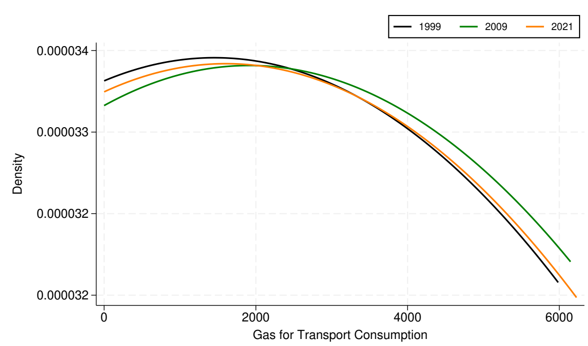
C. Residential: EB Households



D. Residential: Non-EB Households

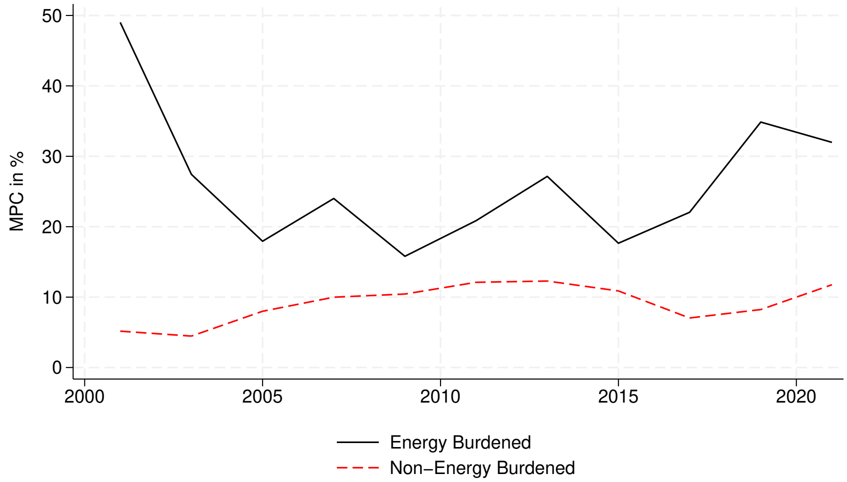


E. Gas for Transport: EB Households



F. Gas for Transport: Non-EB Households

FIGURE A.3: MARGINAL PROPENSITIES TO CONSUME BY YEAR, 1999-2021



NOTE: MPCs are computed using the 2M approach as described in Section 5.

B Appendix: Tables

B.1 Robustness

TABLE A1: HOW ENERGY BURDEN COVARIES ACROSS DIFFERENT HOUSEHOLD PROFILES: PROBIT AND LPM ESTIMATES

Variables	Probit	LPM
Socioeconomic		
Bottom Two Income Quintiles	0.101***	0.113***
Ownership status		
Homeowner	0.016***	0.017***
House size 6+	−0.012***	−0.010**
Type of dwelling		
One family house	0.088***	0.099***
Two family house	0.065***	0.078***
Mobile Home	0.144***	0.157***
Rowhome	0.006	0.028***
Heating		
Gas	0.009***	0.014***
Oil	0.058***	0.056***
Other (propane, wood, kerosene)	0.066***	0.062***
Household characteristics		
Race		
Black	0.073***	0.068***
Asian	0.027*	0.036***
Other	0.043***	0.033***
Hispanic	0.037***	0.039***
Married	−0.045***	−0.042***
Female	0.014***	0.019***
Kids	0.020***	0.018***
Head 65+	−0.040***	−0.047***
Other socioeconomic		
Employed	−0.065***	−0.078***
Postsecondary Education	−0.069***	−0.068***
Subsidized housing	0.029***	0.027**
Heating subsidy	0.126***	0.173***
Behind on Mortgage	0.111***	0.136***
Geographic location		
Northeast	−0.036***	–
Northcentral	−0.028***	–
West	−0.064***	–
Year dummies?	✓	–
State-year FE?	–	✓
Year FE?	–	✓
N	57,248	57,361
R^2	0.176	0.188

NOTE: Asterisks indicate the level of significance of the parameters, * $p < .10$; ** $p < .05$; and *** $p < .01$. LPM clusters standard errors by id-year. Probit reports the Pseudo R^2.

TABLE A2: HOW ENERGY BURDEN COVARIES ACROSS DIFFERENT HOUSEHOLD PROFILES WHO ARE NOT HTM

Variables	Logit
Socioeconomic	
Bottom two income quintiles	0.092***
Ownership status	
Homeowner	0.016***
House size 6+	−0.004
Type of dwelling	
One family house	0.067***
Two family house	0.077***
Mobile home	0.110***
Rowhome	0.001
Heating	
Gas	−0.004
Oil	0.038***
Other (propane, wood, kerosene)	0.036**
Household characteristics	
Race	
Black	0.050***
Asian	0.030
Other	0.049***
Hispanic	0.006
Married	−0.041***
Female	−0.002
Kids	0.029***
Head 65+	−0.025***
Other socioeconomic	
Employed	−0.045***
Postsecondary education	−0.055***
Subsidized housing	0.039**
Heating subsidy	0.138***
Behind on mortgage	0.096***
Geographic location	
Northeast	−0.005
Northcentral	−0.018**
West	−0.042***
Year dummies?	✓
N	25,816
Pseudo R^2	0.179

NOTE: Sub-sample of households who are classified as not hand-to-mouth. Asterisks indicate the level of significance of the parameters, * $p < .10$; ** $p < .05$; and *** $p < .01$.

TABLE A3: MARGINAL PROPENSITIES. 10% APPROACH

	Vulnerable Households	Non-Vulnerable Households
MPC	0.208	0.076
MPCe total	0.052	0.011
MPCe residential	0.010	0.004
MPCe transport	0.026	0.005

TABLE A4: AVERAGE ANNUAL GROWTH RATE (IN %)

	2001	2003	2005	2007	2009	2011	2013	2015	2017	2019	2021
Income											
EB	17.25	11.96	15.40	12.34	10.50	8.43	8.68	10.10	11.48	13.10	14.56
Non-EB	-0.43	-2.95	-1.56	-0.91	-0.54	-4.25	-1.75	-0.13	-0.32	0.91	1.63
Consumption											
EB	0.22	-1.06	1.12	-0.50	-2.90	-2.61	-2.74	-2.67	1.31	0.52	-2.91
Non-EB	2.97	1.55	2.50	2.19	-2.12	-0.05	0.69	0.44	2.52	1.12	1.80
Energy Cons											
EB	-0.11	-13.03	-1.68	-4.24	-14.51	-3.00	-10.27	-13.56	-11.02	-7.45	-13.86
Non-EB	10.56	-1.08	9.17	8.42	-2.52	10.25	0.79	-3.46	-2.34	3.60	-1.92
Residential											
EB	1.83	-9.99	-2.88	-3.72	-4.45	-6.91	-8.25	-1.36	-8.70	-5.52	-11.65
Non-EB	6.49	-1.78	4.03	5.30	4.57	1.39	0.08	3.09	-0.38	3.31	-1.12
Transport											
EB	-0.59	-12.88	1.70	-3.92	-24.59	1.60	-11.30	-24.98	-12.63	-9.26	-14.06
Non-EB	14.73	-1.23	13.61	10.88	-10.49	18.31	2.23	-10.97	-3.39	3.21	-4.13

Note: Growth rates are defined as the log-difference between the variable of interest in wave $t+2$ and in wave t, divided by two to annualize the growth rate.