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DISTRIBUTIONAL IMPACTS OF ENERGY TAXES

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ABSTRACT

Despite popularity among economists for their efficiency, energy pollution taxes enjoy less political support than standards-based regulation because of common perceptions that they burden the poor relative to the rich. However, the literature on pollution tax incidence and consumption surveys in Mexico, the United Kingdom, and the United States, suggest energy taxes need not be as regressive as often assumed. This paper demonstrates that the incidence of such taxes varies according to the energy commodities that are taxed, the physical, social and climatic characteristics of jurisdictions in which they are implemented, and how the revenue is used. It is also shown that the variation in household energy expenditure within income groups is greater than variation across income groups in many cases. These horizontal equity impacts are reviewed, as are their implications for policy making.

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INTRODUCTION

Economists have long-favored pollution taxes and pollution permit trading as mechanisms to control harmful emissions from energy production and consumption. These market-based mechanisms are preferred to more prescriptive instruments like technology, emissions, and fuel economy standards because they yield emissions reductions at least cost.[1] Evaluation of the efficiency characteristics of these policies and alternatives has occupied much of the theoretical and empirical economics literature on pollution control.

By imposing opportunity costs on pollution emissions, these pollution pricing policies tend to raise the price of energy according to the pollution attributed to the marginal fuel unit. It is this transmission of the pollution cost into commodity prices that guarantees least-cost pollution control. But, as with other public interventions, energy price increases can undermine equity objectives, posing an equity-efficiency tradeoff familiar to public economics. In particular, common belief holds that the poor will be relatively more burdened by energy price increases than the wealthy. Absolute incidence analysis that considers tax burdens without regard to the use of proceeds engenders such perceptions.

When equity concerns arise, it is often assumed they can be ameliorated by redistribution of the substantial resource rents associated with inframarginal emissions, e.g., government revenues from pollution taxes or permit auctions. Differential incidence analysis accounts for the distribution of rents associated with environmental policy, which often dwarf net costs to society, indicating a substantial capacity for policy to create winners and losers. Murray et al (2015), for instance, estimate that the rents from proposed regulations of the U.S. power sector approach $200 billion per year, whereas costs of the regulation are $0.5 billion. A tax on carbon dioxide emissions in the U.S. of $15 per ton raises $102 billion in government revenues (Mathur & Morris, 2014). And the global value of carbon pricing instruments in 2015 was $50 billion, though this value has been greater by factors of 2 or more in years when permits traded at higher prices (Kossoy et al., 2015). How these rents are allocated has significant distributional implications (Metcalf 2009b). Energy taxes may impose substantially heterogeneous impacts across income groups, and tax incidence is central to the political economy of energy taxation. Consider, for instance, that a broad-based energy tax in the United Kingdom would raise taxes on 16% of the direct expenditures of the poorest ten percent of households, but would tax only 4% of the direct expenditures of households in the wealthiest income decile (ONS, 2013).

Less frequently addressed than the distribution of energy tax burdens *across* income groups, i.e., vertical equity impacts, is the distribution of energy tax burdens *within* income groups, i.e. horizontal equity impacts. Horizontal inequities may arise from heterogeneity in transportation and housing patterns among households with comparable incomes. For instance, a low-income household may reside in a coastal, city-center apartment, relying exclusively on public transportation and never engaging an air conditioner to cool the home. A similarly poor household might live in a single family home in a less temperate climate and rely upon a long car

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[1] We adopt the shorthand of referring to policies that tax or impose tradable quotas on pollution or polluting production as "energy taxes". This captures our primary interest in the distributional effect of higher energy prices alongside the considerable rent or government revenue associated with market-based policies.

commute to the city center for work. The former, consuming less energy in the home and in transportation, would be considerably less impacted by an energy tax than would be the latter.

Only a few papers address the horizontal equity of energy taxes. A theoretical justification for horizontal equity concerns requires amendments to conventional social welfare functions. But to the extent such inequities are large and of concern, they are more difficult to ameliorate than vertical inequities because the most obvious proxy for unequal effects is the level of energy consumption itself. Subsidies for energy-intensive, energy-taxed commodities or energy-consumption-based transfers would mitigate variation in tax treatment within income groups at the cost of reducing the price signal necessary to efficiently reduce pollution levels.

Amid growing interest in market-based pollution control policy, this paper proceeds to (1) present basic data on household energy expenditures in select countries in order to demonstrate heterogeneity across countries in average fuel expenditures by income deciles, and, consequently, heterogeneity in regressivity of energy taxation; (2) to synthesize the broader literature that addresses under which circumstances and to what degrees are energy taxes regressive; and (3) to demonstrate within-income-decile heterogeneity in energy expenditures that bear on horizontal equity. A discussion of policy implications concludes. Though we refer to energy taxes throughout, we intend that this discussion is directly relevant to proposals to tax carbon. As Metcalf (2009a) and others have observed, “A carbon tax is in large measure an energy tax.” Energy combustion is the predominant source of human-caused emissions, and non-energy sources are often not subject to regulation under existing and proposed climate policies (European Environment Agency 2011).

VERTICAL EQUITY OF ENERGY TAXES

Energy taxes are commonly assumed to be regressive (e.g., Metcalf, 2009a; Rausch, Metcalf, and Reilly, 2011; Williams, Gordon, Burtraw, Carbone, and Morgenstern, 2015), burdening the poor more than the rich. That is, raising the cost of fuels and energy-intensive goods implies a larger percent loss of overall consumption for poorer households because those goods often comprise relatively large shares of low-income household budgets. As Fullerton (2011) observed, these direct effects of policy may also be compounded by indirect and general equilibrium “source-side” effects that further harm the poor via costlier consumption and lower earnings. In particular, earnings among the poor will decline amid pollution pricing to the extent firms substitute clean capital for labor. Such fears figure centrally in the political economy of pollution control, and in particular, climate change mitigation. Recasting a challenge posed by Baumol and Oates (1988) two decades earlier, Fullerton (2011) urged research “to determine whether these fears are valid, and whether anything can be done about them—other than to forego environmental improvements.”

Heeding the challenge of Baumol, Oates, and Fullerton, and the growing policy imperative to understand the distributional impacts of alternative pollution control policies, a relatively recent literature has begun to demonstrate that emissions taxes and tradable permits are not universally regressive. Indeed, the incidence of energy taxes depends upon the fuels and pollutants that are targeted, the characteristics of taxed populations and their communities, how household income is measured, and, importantly, how policy-generated resource rents are distributed.

The conventional view about the regressivity of pollution taxes and tradable permit programs is chiefly attributable to consumption survey data that exhibit energy expenditure shares declining in income. Much as poor households are recognized to spend relatively large shares of income on foods, so, too, are they thought to devote relatively large shares of budgets to energy consumption, a necessity in the developed world second-only to food. The poor are also likely to own older vintages of energy-consuming durable goods like household appliances and automobiles that are less energy efficient than newer models adopted by rich households. Consumption survey data in the U.S. and other countries demonstrate that energy tax incidence varies in predictable, if not commonly considered, ways.

Regressivity of energy tax direct effects

The vertical equity of direct energy tax impacts is assessed by comparing average energy expenditures of households grouped according to proxies of annualized lifetime earnings, typically annual income or annual expenditures. Where the average shares of total expenditures (or income) devoted to energy consumption are decreasing in income across groups, energy taxes are considered regressive because price increases raise the costs of a greater share of consumption for the poor than for the rich. Data from the 2014 U.S. Consumer Expenditure Survey confirm the conventional wisdom that general energy taxes in the U.S. are regressive. The average household in the lowest decile of annual expenditures devotes nearly 15% of its budget to purchases of electricity, natural gas, gasoline, and other fuels, whereas these energy purchases constitute only slightly more than 5% of average total expenditures among households in the highest expenditure decile. This regressivity is depicted in Figure 1, which shows the average energy expenditure as a percent of annual spending by total expenditure decile for U.S. households. It exhibits a monotonic decline of energy budget shares in expenditure deciles, indicating that the direct effects of a broad-based energy tax would impose a greater relative burden on poorer households in the U.S.

Electricity consumption drives much of this regressivity. U.S. households in the poorest expenditure decile devote nearly 7% of total spending to electricity, more than triple the electricity budget share of the wealthiest decile. As shown in Panel A of Figure 2, average household electricity budget shares decline monotonically in total expenditures. This phenomenon is not unique to the U.S. Virtually every country-level consumption survey exhibits a similar pattern. Relying on data from the U.K. Living Costs and Food Survey, a similar pattern emerges for the U.K. (see Panel B of Figure 2), where the variation in average budget shares across the poorest and richest households is even greater than in the U.S. Electricity budget shares decline monotonically—by a factor of eight—from the approximately 8.8% share among the poorest households to barely 1% among the wealthiest.

Analysis of consumption data from Mexico’s 2012 National Survey of Income and Expenditure (Encuesta Nacional de Ingresos y Gastos de los Hogares, 2012) shows a near-monotonic decline in electricity expenditure shares, though the decline is considerably less stark than it is in the

U.K. and the U.S. (see Panel C of Figure 2). Shares are smaller in Mexico compared to the U.S. and U.K., particularly for poor households. This likely reflects differences in both electricity prices and incomes, particularly among the poor, a point to which we return. More generally, Flues and Thomas (2015) estimate virtually universal regressivity of electricity taxes across 21 OECD countries based on expenditure shares. This regressivity has become more pronounced in recent years as electricity prices have increased around the world. In the U.K., for instance, household spending on electricity increased 43% from 2002-2012, with the average household's electricity budget share growing more than 50%. The poorest fifth of households spent 11% of their income on household energy in 2012, up from 8% in 2002. The richest fifth spent just 3% in 2012 up from 2% in 2002 (ONS 2014). Similar patterns are evident in Germany and elsewhere around Europe (BDEW 2016, Eurostat 2013, 2016). In the U.S., in contrast, electricity prices have fallen in real terms due to the expansion of domestic natural gas production.

In contrast to electricity consumption patterns across incomes, transportation fuel consumption patterns suggest that taxes on gasoline and diesel fuels are less regressive than are electricity taxes. In some countries, the direct impacts of fuels taxes appear progressive. Though poorer households in the U.S. devote greater shares of their budgets to gasoline consumption than do the rich, this pattern is reversed elsewhere. In the U.S., gasoline purchases constitute the greatest energy expenditure of the average U.S. household; 4.8% of expenditures are dedicated to gasoline. The poorest households in the U.S. spend 6.5% of budgets on gasoline, compared to only 3% among the richest U.S. households. Excepting the wealthiest decile, however, average budget shares do not differ by more than 1.5 percentage points, as shown in Panel D of Figure 2.

In Mexico, gasoline expenditure shares *increase* in income, suggesting the direct effects of gasoline taxes in Mexico are progressive, rather than regressive. Expenditure shares in Mexico increase monotonically up to the last income decile. The poorest households spend less than one percent of annual budgets on gasoline consumption; the decile with the highest share of gasoline consumption spends four times more of their budgets on gasoline purchases, as shown in Panel F of Figure 2. Fuels consumption in the UK exhibits yet a different pattern. The greatest expenditure shares are incurred by households in the middle of the income distribution, as shown in Panel E of Figure 2. Households in the 6th expenditure decile direct almost twice the share of total spending to gasoline (4.0%) than the richest households (2.2%). The poorest households spend just 1.5% of their budgets on gasoline. Thus, gasoline taxes are progressive in the U.K. up to the 6th expenditure decile, and regressive there beyond.

Elsewhere around the world, heterogeneous consumption patterns indicate that the distributional impacts of the direct effects of transportation fuels taxes are determined by individual country characteristics, including vehicle ownership rates and worker commute patterns. The direct impacts of such taxes are regressive in Austria, Switzerland, Spain, and France, among others. They are progressive in Turkey, where Flues and Thomas (2015) estimate that only one in four of the poorest households operates a motor vehicle compared to three in four of the wealthiest households. Likewise, the direct effects of transportation fuel taxes are progressive in Chile and Hungary, where the ratio of drivers to non-drivers differs across the income distribution by an order of magnitude. Fuel taxes are also estimated to be progressive in China, Costa Rica and Brazil. In Ethiopia, modern transportation in any form is beyond the reach of the poorest households, and so a transportation fuels tax is strongly progressive, as it is also in Ethiopia, Ghana, Kenya, Brazil, Costa Rica, and Kenya (Sterner 2012, Flues and Thomas 2015).

More generally, very low incomes among the poorest households in low and middle-income countries imply that the direct effects of fuels taxes are uniformly progressive in those countries. These assessments, however, ignore indirect effects of fuels taxes, focusing exclusively on household expenditures for transportation fuels. As we later note, such taxes are likely to raise the cost of some public transportation, upon which poor households are relatively more dependent than rich households. Accounting for such indirect effects can change distributional analysis. We must also be careful to avoid using expenditure shares to draw conclusions about existing taxes. To the extent that poor households avoid private vehicle ownership and accept inferior modes of transportation in order to avoid existing transportation fuels taxes, then this averting behavior burdens the households in ways not reflected in cross-sectional consumption data.

Even if direct effects of fuels taxes suggest their progressivity in poor countries, regressivity in richer countries, however, is not implied. Indeed, a transportation fuels tax is regressive in the U.S., but fairly neutral in the U.K., Germany, and France. It is progressive in Sweden. This heterogeneity in direct impact distributions among high-income countries is indicative of differences in commute patterns. In the U.S., low-income individuals are likely to own automobiles that they drive relatively long distances for work commutes. In much of Europe, long commutes are rarer (Stutzer & Frey, 2008). Further, robust public and mass transit systems serve to lower the share of private vehicle use (Haghshenas & Vaziri, 2012). Hence, poor households in the U.S. may be particularly disadvantaged by gasoline taxes.

Flues and Thomas (2015) estimate slight regressivity of heating fuels taxes across 21 select OECD countries, though in some instances, e.g., Germany, the taxes are estimated to be progressive. The regressivity of heating fuels taxes is moderated to the extent that poor households live in smaller and multifamily homes with less area to heat and less heat loss (Hernández, 2014). On the other hand, the regressivity of heating fuel taxes may be exacerbated if poor households live in older, less efficient housing stock and own older, less efficient household appliances. In India and Tanzania, taxes on biomass and kerosene are highly regressive (Datta 2012; Mkenda, Mduma, Ngasamiaku 2012).

Much as vehicle ownership rates and other characteristics of transportation infrastructure induce variation in consumption shares across income groups within countries and within income groups across countries, so to do the magnitudes of consumption shares devoted to other energy commodities differ in predictable ways. For instance, natural gas budget shares decrease monotonically in total expenditure deciles in the U.K., but they increase monotonically in Mexico. The difference is reflective of high dependence upon natural gas for home heating in the U.K. Not only does Mexico have lower demand for home heating because of its relatively warmer climate, but lower per capita incomes also depress the rate of home heating capital adoptions in Mexico relative to the U.K. While incomes are similar across the U.S. and the U.K., the U.K. climate requires little home cooling, whereas air conditioners consume considerable electricity across large portions of the U.S. due to high seasonal temperatures. Consequently, the level of spending on electricity in the U.S. is much higher than it is in the U.K. In spite of

Mexico's warm climate, electricity budget shares in Mexico are relatively low, likely due to low air conditioner penetration rates in Mexico (Davis, Fuchs, & Gertler, 2014). In developing countries, where rates of residential electrification are low, the generally regressive electricity tax may exhibit progressivity.

The progressivity of the direct effects of energy taxes can be summarized by the Suits coefficient, a tax incidence measure analogous to the Gini coefficient.[2] It is calculated as the share of area below a 45-degree line that falls between the 45-degree line and a Lorenz curve that depicts the relationship between cumulative tax share and cumulative income share. Positive Suits values reflect progressive taxes, whereas negative values reflect regressive taxes. By construction, the index is bounded by -1 and 1. The Suits index is useful for defining whether the direct effects of particular taxes are progressive or regressive when expenditure shares do not increase or decrease monotonically across income groups and have distributional impacts that are ambiguous upon visual inspection. Perhaps more importantly, the Suits index provides a single-valued index with which to more easily compare the progressivity of alternative taxes or common taxes imposed in different jurisdictions. For example, Figure 3 maps the Suits index of a uniform tax on home energy consumption for 30 countries based upon analysis of Eurostat data. The energy expenditures reflect home heating, cooling, and electricity costs. The Suits coefficients for all but one of these countries is negative. In only the Former Yugoslav Republic are home energy taxes progressive. This corresponds with the intuition that energy taxes will be more progressive in countries with low incomes that put energy-consuming durable goods beyond the reach of poor households. There is, however, no strong relationship between per capita incomes and home energy tax regressivity, reflecting the importance of country-specific housing and climate characteristics. Such taxes would be only slightly regressive in Finland and Sweden, suggesting regressivity may partly depend upon inequality in the overall income distribution.

Accounting for indirect effects of energy taxes

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[2] Define the Suits coefficient, S, as:

$$S = 2\int_0^1 \big(y - T(y)\big)dy,$$

where *y* indexes the cumulative share of total national income (or total expenditures) earned by households ordered from poorest to richest. The function *T* is cumulative share of a particular tax paid by those households earning *y*. For example, suppose the poorest 40 percent of households earn y = 20 percent of national income. And suppose, for a particular tax, those households paid 10 percent of the total tax burden. Then, $T(0.2) = 0.1$. By construction, $T(0)=0$ and $T(1)=1$. The Suits coefficient is equal to zero for a proportional tax, less than zero for a regressive tax, and greater than zero for a progressive tax. It is bounded by -1 and 1. An approximation for use with decile-level aggregation computes the Suits coefficient as:

$$S = 1 - \sum_{i=1}^{10}[T(y_i) + T(y_{i-1})](y_i - y_{i-1}).$$

The foregoing analysis has the benefit of simplicity and transparency; it relies only upon assessment of primary consumption data, typically obtained by household surveys. But it considers only the direct incidence of energy taxes, ignoring indirect effects of higher energy costs and of behavior changes undertaken by firms and agents to avert energy taxes. An accounting of indirect effects can dramatically change incidence analysis. For instance, as Sterner and others have noted, public transportation and taxi services are among the industries most exposed to fuel taxes. Their costs are likely to increase in proportion to their respective fuel cost shares. The distributional impacts of fuel taxes will therefore depend upon the relative dependencies of rich and poor households on transportation services. In Mexico, for instance, the direct effect of fuel taxes is progressive, but because the poor spend about 12% of annual budgets on public transportation and the rich spend essentially nil, the regressivity of indirect transport effects yields a net effect of fuel taxes on transportation-related expenditures that is slightly regressive (Sterner & Lozada, 2012). In Costa Rica, a gasoline tax is estimated to be progressive whereas a diesel tax is estimated to disproportionately burden the poor because diesel is predominantly used in public transportation. In Europe, the distributional impacts of fuel taxes are not changed when indirect transportation effects are considered, whereas fuel tax progressivity increases in poor countries like Ethiopia and China (Mekonnen, Deribe, & Gebremedhin, 2013; Sterner & Cao, 2012; Sterner & Carlsson, 2012).

Alternative methods of tax incidence analysis account explicitly for indirect effects of energy taxes in economy-wide energy tax incidence analysis. Employing methods pioneered in this context by Fullerton (1995) and Metcalf (1999), several studies of carbon tax incidence have accounted for indirect tax impacts by tracing the effects of higher primary fuel costs through the economy using input-output (I-O) matrices that relate industry outputs to inputs of other industries. Whereas low-income households are disproportionately impacted by the direct impacts of some energy taxes because of the relatively large budget shares they devote to some direct energy expenditures, they are likely to be less affected by indirect impacts than high-income households.

In general, to the extent that high income households consume more overall, then an accounting of indirect effects of energy taxes is expected to increase the progressivity of the taxes (Hannon, Stein, Segal, & Serber, 1978; Herendeen, Ford, & Hannon, 1981). Bull, Hassett, and Metcalf (1994) evaluate the direct and indirect effects on U.S. households of a $0.27 per Btu tax on select energy commodities, including coal, gasoline, natural gas, and electricity. Using input cost shares of 82 commodities, they estimate that the Btu tax directly increases the cost of the various energy commodities by 3-16% and induces indirect cost increases on other goods ranging from 1-2.5%. More than half of the average household burden of the Btu tax is estimated to be attributable to indirect tax impacts. The direct effect of the tax is regressive, but the indirect component of the tax is progressive, yielding a tax that is on net approximately proportional, though slightly regressive.

Mathur and Morris (2014) use similar methods to estimate the incidence of a tax of $15 per ton of carbon dioxide emissions. They estimate that indirect effects constitute less than one-third of the tax burden for low consumption deciles and more than half of total burden for high-consumption deciles. Accounting for indirect effects, yields a carbon tax that nevertheless appears to be modestly regressive on net; poor household expenditures increase more than two percent whereas rich household expenditures rise by 1.3%. Indirect tax impacts are greatest among the air transport, other transport, automotive parts, food at work, and recreation expenditure categories of the U.S. Consumer Expenditure Survey (Mathur and Morris 2014).

Such I-O approaches account for indirect effects of energy taxes as higher energy costs raise the costs of inputs across industries. But they, too, assume no behavior change. As Hassett, Mathur and Metcalf (2011) note, higher prices for industrial inputs and consumer products will induce substitution away from carbon-intensive items, eroding the carbon tax base, but lowering the burden for agents by less than tax collections fall because of the costs of averting behavior. Analyses that hold consumption quantities constant thus constitute first approximations of impacts. They are more reflective of impacts in the short-run when options for averting higher prices are minimal.

In the longer run, averting behavior and substitutions certainly make demand more elastic. The averting behavior is presumably less costly than the avoided tax, so agent welfare rises relative to the short-run effect. Elastic demand also implies that tax-induced price increases may not be fully passed onto consumers but may, instead, be passed backward onto owners of capital and energy resources. Studies employing a third analytical approach, that accounts for behavior change, suggests regressivity is overstated in short run analyses to the extent owners of capital and natural resources are higher income (Bovenberg and Goulder 2001; Metcalf et al. 2008). Such computable general equilibrium (CGE) models can also account for innovation, which may have distributional consequences, too. CGE models, however, must impose numerous assumptions about the functional forms of supply and demand that afford them less transparency. CGE models and simpler partial equilibrium models (which allow behavioral change in some but not all markets) also employ energy price statistics that may vary in their fidelity around the world.

Measurement issues

The incidence of energy taxes depends upon the taxed energy commodity and the setting in which the tax is imposed. The estimation of such incidence also depends upon whether indirect effects and behavior change are considered. It also depends critically upon how income is measured. Stratification of households by annual expenditures, as is done here, is commonly preferred to annual income measures of tax incidence because expenditures track more closely lifetime income than does contemporaneous income (Poterba, 1991). Annual income is subject to shocks due to spells of unemployment, health problems, and changes in family conditions that exaggerate the regressivity of energy taxes (Poterba, 1989; Bull, Hassett, & Metcalf, 1994). Annual income also exhibits well-known lifecycle patterns in earnings and asset accumulation, which cause them to reflect poorly the current or future economic circumstances of some subsets of the population, e.g., young workers and the elderly. Under the Permanent Income Hypothesis (Friedman, 1957), annual consumption is less sensitive to shocks and exhibits less severe life cycle patterns than does annual income because of consumption smoothing behavior.[3]

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[3] Bull, Hassett and Metcalf (1994) observe in U.S. Consumer Expenditure Survey data that consumption tends to closely follow income, exhibiting a “marked hump-shaped pattern” over lifetimes, rather than the relatively flat consumption pattern posited by the Permanent Income Hypothesis. Therefore, they account for energy tax incidence

Incidence calculations that rely upon annual income as opposed to annual consumption tend to exhibit greater regressivity of electricity, gasoline, and broad-based energy taxes. Even the distinction between progressive and regressive can change. For example, Sterner (2012) finds regressivity is exaggerated by income-based measures in France, Germany, Spain, Sweden, and the UK. And, whereas annual income strata reveal fuel taxes in Germany and Sweden to be regressive, expenditure strata indicate they are, instead, progressive. Use of expenditure strata also render progressive taxes in China more neutral than income strata suggest.

Addressing vertical equity concerns

Given fuel-specific heterogeneity in tax incidence, distributional objectives may be better accommodated by fuel-specific or sector-specific policy. Yet a basic tenet of microeconomics dictates that efficient pollution control policy not preferentially target particular sources of emissions. Rather, all polluters should face a common price per unit of pollution in order to achieve least-cost abatement. Fowlie, Knittel, & Wolfram (2012), for instance, estimate that the heavy regulation of pollution from smokestacks relative to emissions from automobile tailpipes raises the cost of pollution abatement in the U.S. by $1.6 billion annually. Nevertheless, source-specific policies may be more expedient for historical, technological, or political economy reasons, including distributional reasons.

At the same time, low budget shares for energy in some countries, including Finland, France, Ireland, Mexico, and Spain, suggest that distributional concerns in these countries may be over wrought, irrespective of the country and fuel-specific incidences of prospective taxes. In these countries, energy expenditure shares are 5% or lower for the poorest 20% of households, implying a burden of only several hundred dollars even from energy taxes that increased energy costs by one-half. The distributional impacts of the generally regressive electricity tax are also relatively small. The average U.S. household spends 4% of its annual budget on electricity. In Mexico, the electricity expenditure share is only 2%. These small expenditure shares limit the magnitude of income redistribution accomplished via the direct effect of energy taxes regardless of differences in consumption shares across poor and rich households.

Rather than reducing the pollution tax or ignoring its distributional effects, one could marry a regressive energy tax with a progressive redistribution of revenues. Distinct from other forms of environmental regulation, pollution taxes generate government revenues that can be used to accomplish government objectives, including neutralizing the distributional impacts of the pollution taxes themselves, e.g. via new transfer programs or adjustments to existing taxes and transfers. A number of economic studies have considered the differential incidence of energy taxes under various assumptions about how energy tax revenues would be expended. As Metcalf (2009b) observes, the use of proceeds bears critically on distributional impacts. Mathur and Morris (2014), for instance, estimate that if 11% of revenues from a $15 tax per ton of carbon dioxide were returned to the poorest twenty percent of households in some way, then these households would, on average, be no worse off because of the carbon tax. Tradable permit programs can similarly generate revenues if the permits are auctioned by the government, though

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on lifetime consumption by relating household consumption to typical lifetime consumption profiles for similar households.

alternative allocation mechanisms generate rents elsewhere in the economy and introduce distinct equity impacts.

The recycling of pollution tax revenues can have important efficiency and distributional implications. In fact, the earliest literature considering pollution tax swaps, dating at least to Tullock (1967), focused on the efficiency improvements associated with substitution of pollution taxes for distortionary taxes, independent of environmental improvements. Because environmental taxes also introduce efficiency costs, the sign and magnitude of the net efficiency improvements from pollution tax swaps vary according to which taxes are adjusted (Bovenberg & de Mooij, 1994; Carbone, Morgenstern, Williams III, & Burtraw, 2013; Cramton & Kerr, 2002; Fullerton & Metcalf, 2001; Goulder, 1995, 2002; Goulder & Bovenberg, 2002; Goulder, Parry, Williams III, & Burtraw, 1999; Parry, 1995; Parry & Bento, 2000).

Efficiency goals in revenue recycling may also be at odds with objectives of neutralizing the regressivity of the pollution taxes, themselves. For instance, lump sum, homogeneous per capita rebates achieve progressivity of the pollution tax and rebate package, but they do not improve marginal work incentives, which are diminished by the pollution tax (Goulder, 1995; Rausch et al., 2011). A reduction in marginal income tax rates would reduce distortions in the labor market, and dramatically lower the cost of pollution taxes, but at the cost of burdening the poorest households three times more than the richest households in relative terms (Dinan, 2012; Goulder, 1995; Parry & Bento, 2000; Rausch et al., 2011; Rausch & Reilly, 2012). Only 30 percent of households in the lowest income quintile and 64 percent of households in the second-lowest income quintile would benefit from a reduction in income taxes (Dinan, 2012).

Dinan (2012) enumerates potential revenue and expenditure mechanisms to address distributional concerns and highlights the challenges in ensuring low income households are made whole and economy-wide costs are minimized. For instance, a revenue-neutral payroll tax rebate on the first $3,660 of earnings would return $560 per worker, sufficient to compensate the average low-income household for the cost of a tax equal to $28 per ton of carbon dioxide. It would be progressive across households with earnings, providing benefits that constitute a greater share of income to poor households. But households without earnings—just less than half of all households in the lowest fifth of the income distribution—would be uncompensated. Recycling of pollution taxes via increased generosity of existing transfer programs could also reduce pollution tax regressivity, though recipiency varies considerably even within low income deciles. Automatic indexing of transfer programs and the tax system also contributes marginally to reducing regressivity of pollution taxes (Dinan, 2012).

Metcalf (1999) develops one potential revenue-neutral, non-regressive pollution tax swap. The proposal raises $126 billion in revenues from taxes on carbon, sulfur dioxide, nitrogen oxide, and particulate matter emissions and from gasoline and diesel purchases. These fund a four-percent across-the-board income tax cut, a $150 income tax credit per person, and an exemption from payroll taxes for the first $5,000 in earnings. The environmental taxes are equal to seven percent of income for households in the lowest annual income decile and 1.6% for wealthy households. The revenue recycling blunts the tax regressivity, with approximately the bottom third of the income distribution receiving tax reductions equal to four percent of income. The top third of the distribution receives cuts equal to 1.5-2.7% of income. Still, the net effect of the tax reform is to reduce the progressivity of the tax system, as the upper half of the income distribution receives tax cuts and the lower half incurs tax increases. Comparing effects on the basis of a lifetime income proxy (see Metcalf 1999), the tax swap looks more progressive, with small tax cuts received by households in the middle eight deciles of the income distribution. No group's tax burden changes by as much as one half-percent of annual lifetime income. The progressivity could be enhanced by scaling payroll tax exemptions to family size and by increasing the refundable tax credit to $300 per exemption.

ENERGY TAX IMPACTS ON HORIZONTAL EQUITY

Most discussions of equity focus on whether a policy creates a more or less equitable distribution of income. This is determined by the average policy impact for individuals at various income levels as captured visually by figures in the preceding section as well as quantitative measures like the Suits index. A progressive policy puts a proportionally higher burden on richer families and, by construction, leads to a more equitable income distribution.

The emphasis in the literature on the extent of vertical equity ignores welfare changes occurring to households *within* income groups. For example, a payroll tax reduction financed by a pollution tax may raise the income of some households in the lowest income decile and lower the incomes of others. This within-income group heterogeneity in impacts does not affect evaluations of regressivity that have occupied much of the previous literature. Nevertheless, such unequal policy treatment of households in equal income positions may bear on social welfare or the policymaker's objective. One place we have seen such a focus is regarding regional impacts (e.g., Blonz et al 2010; Bull et al 1994; Mathur and Morris 2014)

With coarse income categories, e.g., quintiles or deciles, incomes will vary non-trivially within income groups. But even for households with identical incomes, policy impacts may vary due to household characteristics. One household may be located in a temperate coastal region and comprised of earners who walk to work. Another household may be located in a community with a less-forgiving climate, long work commutes, and limited public transit. Thus, the impacts of pollution taxes and any revenue recycling will vary across households of similar incomes according to climate, characteristics of the electricity generating fleet, housing stock, and energy efficiency of household durables, as well as commute distance, job density, transportation infrastructure, income sources and transfer benefits recipiency, among perhaps other characteristics. While capital investments, e.g., energy efficient durables, can mitigate the tax burden over time, such investments themselves constitute burdens to households as do other averting behaviors. In the case of capital investments, poor households may be capital constrained so that such investments become more difficult for very households facing the largest increase in energy expenditures. This could exacerbate inequality over time. Narrower income slices of the data will not eliminate this heterogeneity, and, therefore, will not eliminate observed inequities in policy treatment.

Such horizontal inequity may be important for at least several reasons. First, a progressive tax reform would surely be viewed less favorably by those concerned with equity if the apparent progressivity is a consequence of massive, positive gains to a few winners within low-income groups. This would be even more likely if the gain of few winners concealed broad, if small, harm to a majority within the same low-income group. Second, the shares of winners and losers and the magnitudes of their gains and losses may have political economy implications. For instance, political support for a policy may require a broad set of winners within income classes. Alternatively, the minority with much to gain or lose from policy reform may be more likely to exert effort to influence political outcomes. This likely motivates interest in regional impacts, given the connection to political representation in government. Third, society may conclude that it is simply unfair to effectively tax individuals with the same income differently. A number of authors have articulated this perspective, though not without considerable debate, a discussion of which we return to briefly below.

Measuring and Understanding Horizontal Equity

Whether horizontal equity matters to society surely depends on the degree of heterogeneity within income groups. And yet, there is relatively little work in the literature concerning any heterogeneity of energy tax effects within income groups. Poterba (1991), an early exception, shows considerable within-decile variation in gasoline expenditure shares even though gasoline expenditure shares do not vary considerably across income groups. Variability in expenditure shares is also revealed to be greatest among low income groups. For instance, one-third of lowest-income-decile households incur no gasoline expenditures, but about one-sixth spend more than 10% of total expenditures on gasoline. In the highest income decile, in contrast, all households incur some gasoline expenses and none spends more than 10% of annual budgets on gasoline. Unsurprisingly, then, when Rausch et al. (2011) simulate the effects of a carbon tax in the United States using the Consumer Expenditure Survey, they find significant variation in incidence within income groups, particularly among low income groups. Indeed, the interquartile range (25th to 75th percentiles) among the lowest decile includes the mean expenditure shares across all the other deciles. Thus, intra-class variation among the poorest households exceeds variation in mean impacts across income groups.

This kind of variation in energy expenditures can be seen graphically for the U.S., Mexico, and the U.K., in Figure 4. For each expenditure decile, and for each country, the figure shows the interquartile range of expenditure shares (from the 25th to the 75th percentile, "the box") along with the range of values that are within 1.5 times the interquartile range ("the whiskers"). Panels A to C show intraclass expenditure shares variation for electricity, and panels D to F do similarly for gasoline.

For electricity (panels A-C), we see the same consistent pattern reported by Rausch et al of considerable within-decile variation. There is more variation in expenditure shares for the poorest households than for the richest households, with a monotonic decrease in between. For the U.S. and U.K. (panels A-B), the variation in electricity shares across deciles appears comparable to within-decile variation. But the within variation is still large: Expenditure on electricity reaches 20 percent for some households while others have no (direct) expenditures. Some in the UK even have negative expenditures, reflecting various rebate programs. For Mexico (panel C), we noted earlier that the variation across deciles was smaller than in the U.S. and U.K., and here we see it is smaller than the within-decile variation as well.

Expenditure shares for gasoline (panels D-F) only amplify the idea that within-decile variation is larger than across-decile variation. For gasoline, the interquartile ranges for the decile with the most variation (#1 for the U.S., #6 for the U.K., and #8 for Mexico) encapsulate the medians – if not the interquartile ranges – of all the other deciles. For the U.K. and Mexico, this reflects a very large number of people with no direct expenditures on gasoline. In the U.S., fewer households are without expenditures, but the interquartile range of 3 to 8 percent for the poorest decile still almost spans the interquartile ranges for the other nine deciles. Only the 75th percentile for the 4th decile is slightly higher.

Thus, there appears to be more than enough variation within income groups to consider horizontal equity concerns. Moreover, the level and variation is greater than the variation in tobacco or alcohol expenditures, which can also have unpriced social costs. They have an interquartile range of only 0-1 percent (or less) for all deciles in the U.S. These micro data from national consumption surveys demonstrate that energy expenditures vary non-trivially within income groups. In many cases, such variation exceeds variation in expenditure shares across income groups. The data also reveal that many low income households would be unaffected by taxes on specific fuels because they consume none of them. For example, in the U.K. and Mexico, more than 75 percent of poor households has no gasoline expenditures. This includes the lowest decile in the U.K., and the lowest *three* deciles in Mexico.

Social Welfare Theory

Even with the relatively large horizontal equity effects suggested in these figures, their implications for policy are not obvious. There has been considerable debate in the academic literature about the theoretical basis for horizontal equity considerations. Whereas vertical equity concerns can be motivated by reliance upon a utilitarian social welfare function and declining marginal utility of income, horizontal inequities stem from *changes* in net incomes for households of the same income levels. This requires going beyond a conventional social welfare function. In particular, concern about horizontal equity must give the initial position (prior to the energy tax) some special status so that deviations from that position are an appropriate welfare metric.

Kaplow (1992, 2000) has presented forceful arguments against horizontal equity as a distinct construct. Why should variation in policy outcomes for otherwise similar individuals be viewed as any different from a lottery? And, if viewed as a lottery, what is the basis for an initial position receiving special status?[4] Others have taken a decidedly different view. Even if a public policy acts like a lottery, it is not (Musgrave 1990). Winners and losers arise based on rules determined by government, not luck. Another possible argument for horizontal equity comes from recent work on preferences, framing, and context. There is little doubt that individuals themselves are influenced by relative incomes, in addition to absolute levels of income (e.g., Easterlin 2003), though it is not obvious what this implies for welfare (Shafir 2016).

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[4] Kaplow has argued out that, viewed as a lottery, horizontal equity concerns can lead to a violation of the Pareto principal, as society might fail to enact a policy that was preferred by the individuals facing it.

It is certainly possible to define welfare functions in terms of changes in income (e.g., Auerbach & Hassett, 2002; Bourguignon, 2011; Slesnick, 1989). A focus on changes conveys special welfare significance to the pre-policy status quo – that either it does not matter at all or that the income level associated with the status quo is valued differently than changes in income associated with the policy. As suggested by the above references, this notion has been the focus of a spirited debate—one we have no hope of settling here.

Concerns in Practice

Even for those inclined to value horizontal equity, concern about the horizontal equity impacts may at least partly depend upon the inevitability or invidiousness of inequities. That is, the extent to which averting behavior can reduce inequities at low cost. For example, we know that within-income-group variation in energy expenditures is attributable, at least in part, to regional variation in climate and geography (Aldy et al., 2010; Rausch et al., 2011). To our knowledge, however, the fraction of horizontal variation that can be explained by such physical characteristics of regions is poorly understood (Pizer, Sanchirico, & Batz, 2009). It is generally suggested that other demographic characteristics (beyond income and geography) play a smaller role in energy costs within income groups. But this research typically lacks information about housing or commute characteristics, which likely cause a substantial degree of variation. Very little is known about how individual behaviors—like thermostat or water heater settings—induce variation in energy consumption.

If the latter is a large driver of intra-class heterogeneity, and if it can be diminished by low cost behavioral changes among policy "losers", then observed variation in energy consumption should weigh less heavily among equity concerns. Changes in household appliance settings, for instance, can occur quickly and at low pecuniary and time cost, and perhaps at very low total cost. Changes in household location, housing stock, place of employment, commute mode, and energy efficiency of household durables are much costlier in the short run, and, therefore, are likely to occur more slowly. To the extent these differences drive intra-class variation, then horizontal inequities may be more persistent, less readily resolved, and of greater ethical concern.

Regardless of one's perspective on this ethical debate, there is clearly a practical issue associated with characterizing the effects within income groups. Figures relating energy expenditure shares to income deciles simply do not communicate to policymakers what are the full set of distributional impacts. And the intra-class changes clearly matter in a political economy sense. Swapping incomes among an income class, for example, may not affect the vertical equity at all. But it clearly creates opposition among the one-half of affected individuals who must be worse off.

It is also more difficult to ameliorate horizontal equity effects compared to vertical equity effects. That is, much of the literature on vertical equity effects emphasizes the ability of planners to adjust those effects with suitable changes to income taxes or other taxes and transfer programs. It is less obvious how one might mitigate horizontal effects from energy taxes without attenuating the efficiency gains of the energy tax, itself (e.g., by simply using lower energy tax rates). One-time transfers based on historical use could compensate policy losers for durable investments made in the absence of policy. But it is not obvious where to find the data to implement such transfers. Moreover, even with perfect information on such exposure, such one-time transfers may over-compensate. One may consider, for instance, that forward-looking households have anticipated energy taxes, and such prices were already capitalized in asset prices at the time they were acquired.

Alternatively, one could focus on the variation due to geographic location. The federal government could rebate some portion of the energy tax revenue to households via states, counties, or perhaps utility service areas, in well-defined geographic areas. Based on aggregate energy demand information for the region, such an approach could reduce inequality across regions. It would also diminish energy tax efficiency by muting the choice to migrate *across* regions, but it is unclear whether such a margin is significant or not. In addition, other sources of within-region variation would remain unaddressed.

POLICY IMPLICATIONS

What are we to make of the observed variation in energy expenditures and literature on distributional effects of energy taxes? We see five takeaway messages.

1. *Energy taxes are not always regressive, particularly gasoline taxes in poorer countries.* Though pollution taxes are often assumed to burden poor households relatively more than rich households, it is evident this common belief is not always correct. The incidence of pollution taxes varies along at least several dimensions. First, the regressivity of any particular pollution tax depends upon the taxed commodity. As we have shown, electricity taxes tend to be highly regressive, whereas gasoline taxes are less regressive, and may be progressive in some settings and over some ranges of income. Secondly, a country's overall level of economic development is important. Energy taxes in general, and gasoline taxes in particular, tend to exhibit progressivity in less developed countries wherein the poor may not have electrified homes or access to automobiles or affordable public transportation. Third, the incidence of energy taxes varies according to the climate and cultural characteristics of jurisdictions, along with features of the housing stock and transportation and electricity generation infrastructure. Thus, the regressivity of gasoline taxes differs across comparably rich countries like the U.S., with its longer commutes and less extensive public transport, and the U.K. Such taxes are highly regressive in the U.S. and, yet, exhibit progressivity over low to middle incomes in the U.K. In addition to contextual differences across countries, conclusions about regressivity can be influenced by measurement. Regressivity is diminished when evaluated using proxies for lifetime earnings, e.g., annual expenditures, as opposed to annual earnings. The former is widely considered by economists to better measure the well-being of households but is more difficult to observe and measure. Regressivity is also generally reduced when indirect tax effects are considered in addition to the direct effects upon which some of the literature focuses exclusively.

   The regressivity of energy taxes is likely to change over time. In particular, as incomes grow in developing countries, we would expect regressivity to increase based on observed consumption patterns. Moreover, holding energy consumption fixed, regressivity may be expected to grow even more if incomes grow disproportionately among the rich or if energy prices grow faster than incomes.

2. *Variation in energy expenditure shares is typically larger within rather than across income groups.* The horizontal equity impacts of energy taxes are less remarked upon than the vertical equity implications. Yet, there is evidence that within-income-group variation in tax burden exceeds that variation across income groups. This intra-class variation tends to be greatest for the poorest households, some of whom consume no gasoline or electricity while others devote 20% or more of their budgets to purchases of either electricity or gasoline. Such variation among households of similar incomes stems from differences in climates, geography, built environment, and households' characteristics and behaviors. Some behaviors like thermostat settings can be easily changed to avoid higher tax burdens, but other characteristics like commute length and housing characteristics are immutable except by changing jobs or moving. On the one hand, this points to a significant potential for disadvantaged groups—identified by region or other demographic commonality—to mobilize political opposition in the face of such taxes. On the other, there is a longstanding ethical debate on the extent to horizontal equity should matter for social welfare or other objectives of a planner.

3. *Even if energy taxes change resource distributions, the cause for policy concern is not pre-ordained.* To the contrary, in some settings, the direct expenditures on particular energy commodities comprise only a limited portion of household budgets. In Mexico, average electricity expenditure shares do not exceed 2% across all income deciles. Such small expenditure shares, thus, limit the magnitude of redistribution that is induced by energy taxes, and, in particular, limit the losses to those poor households that are hurt by regressive energy taxes. Indeed, as Dinan (2012) noted, even a substantial tax on carbon equal to $103 per ton would impose added costs on the average lowest-income-quintile household of $425 per year.

4. *Unlike other forms of regulation, energy taxes generate revenues that governments can use to accomplish distributional goals, at least regarding regressivity.* Thus, even in settings where energy taxes would impose relatively greater burden on the poor, a series of transfers or changes to other taxes can theoretically be devised to (1) make income populations whole, at least on average, or (2) design a proportional, or distributional neutral tax reform, or (3) perhaps, even to increase the progressivity of government tax and transfer programs. In recycling the revenues of energy taxes, however, planners face a tradeoff between accomplishing progressivity and achieving efficiency. The costs of energy taxes, particularly the tax interaction effects, can be minimized by reducing other distortionary taxes, but the most distorting taxes also tend to be the most progressive, such that tax rate reductions yielding the greatest cost reductions also exacerbate regressivity.

   While vertical equity concerns can be ameliorated by devising tax swaps, they likely will leave in place horizontal inequity because of variations within income classes. For example, capped reductions in payroll taxes financed by energy taxes can improve progressivity but do not aid households without any earnings, including the unemployed and retired. Admittedly, to the extent such households are recipients of indexed transfers and benefits, then the price increases induced by higher energy costs will translate into somewhat more generous benefits from such programs, e.g. Social Security (Rausch et al 2010; Fullerton, Heutel, and Metcalf 2012.) Achieving horizontal equity would require not only targeting non-earners, but also compensating relatively more those households that consume more electricity. But rebates dependent upon current (or post-policy) energy consumption serve to reduce the price signal that the energy tax induces in order to avoid the externality-induced deadweight loss to begin with. Thus, eliminating horizontal equity comes at a potentially high efficiency cost. One-time rebates could be offered to households in hot climates or to households with long-commutes to compensate them for the policy-induced devaluation of long-lived investments. Such one-time rebates, if not predicted by households, have the benefit of avoiding distortions to behavior. It may, however, lead to overcompensation if the energy taxes themselves were predicted and capitalized.

5. *In summary, energy taxes are a cost-effective policy to address energy externalities but raise legitimate distributional concerns in some cases that may or may not be easily rectified.* Policymakers frequently face efficiency-equity trade-offs in designing public policies. With energy taxes, revenues can help reduce distributional problems to an extent. But if horizontal equity is a concern, then more costly (less efficient) regulation may be desired. For example, choosing energy efficiency standards for homes, cars, and appliances over energy taxes may lead to uneconomic and suboptimal investment. And, by not raising the price of electricity, such standards will fail to incentivize other energy saving behavior. But these higher societal costs may come with more modest distributional impacts making such standards a better choice. Alternatively, it may be desirable to introduce energy taxes more gradually as less-malleable household behaviors become changeable.

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FIGURES AND TABLES

Figure 1: Average U.S. Household Energy Expenditure as Percent of Total Expenditure by Expenditure Decile

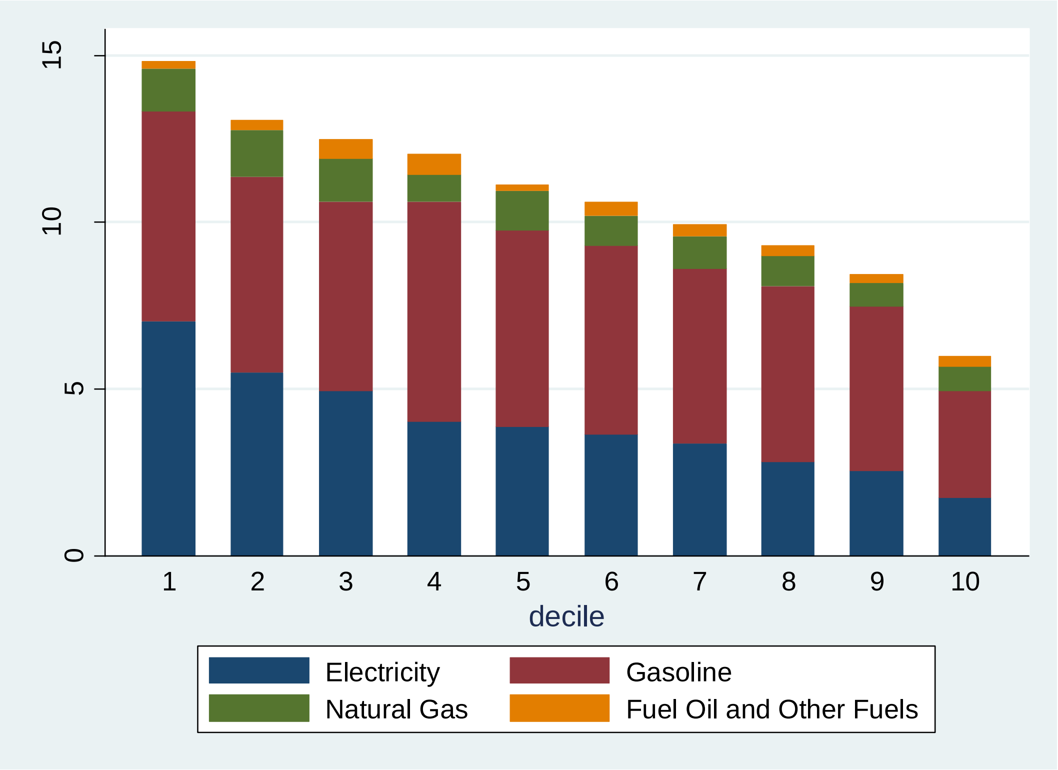
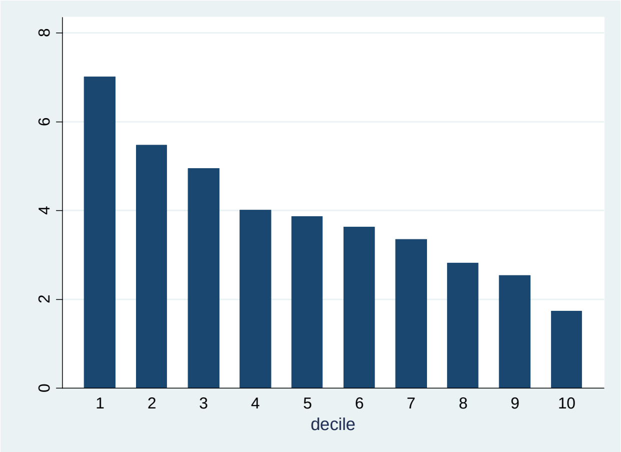
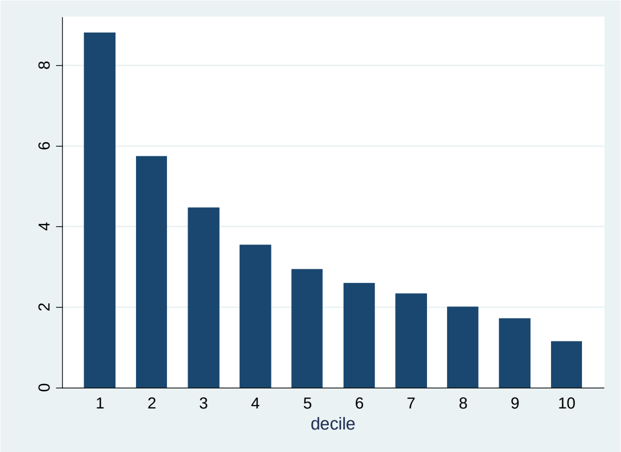


Figure 2: Average Electricity and Motor Fuels Expenditures as Percent of Total Spending for U.S., U.K. and Mexico Households by Expenditure Decile

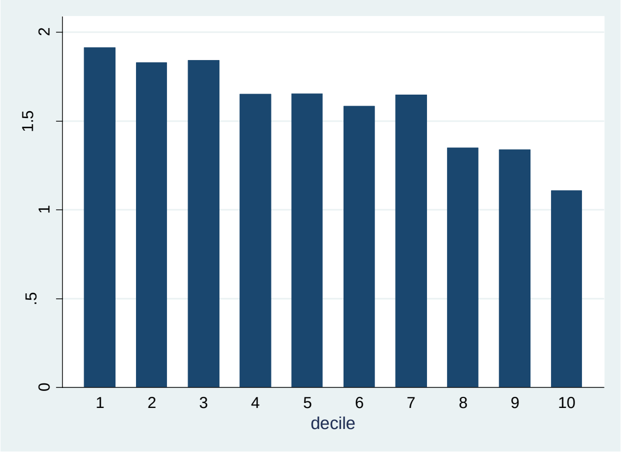
Panel A: Electricity: USA



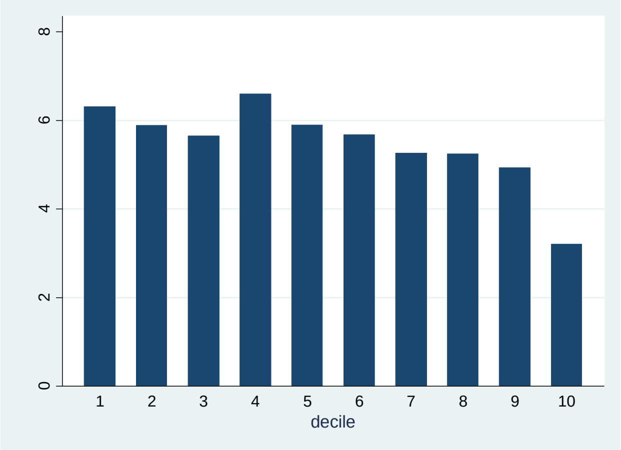
Panel B: Electricity: U.K.



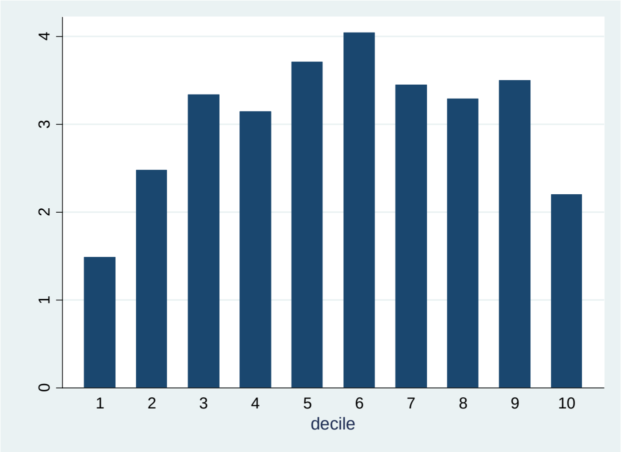
Panel C: Electricity: Mexico



Panel D: Motor fuels: U.S.



Panel E: Motor fuels: U.K.



Panel F: Motor Fuels: Mexico

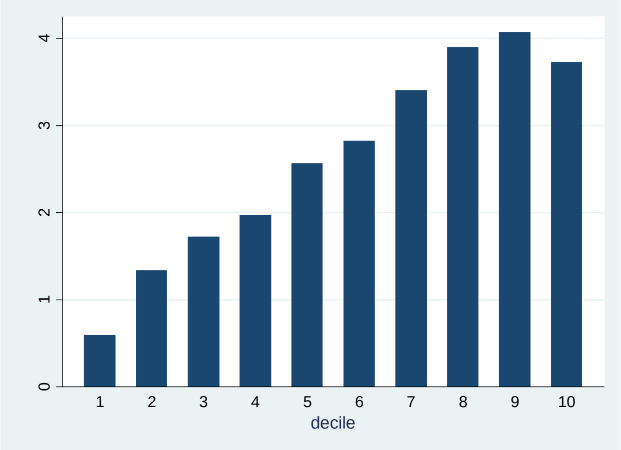


Figure 3: Suits Index for 30 European Countries (possible range is -1 for the most regressive to +1 for the most progressive).

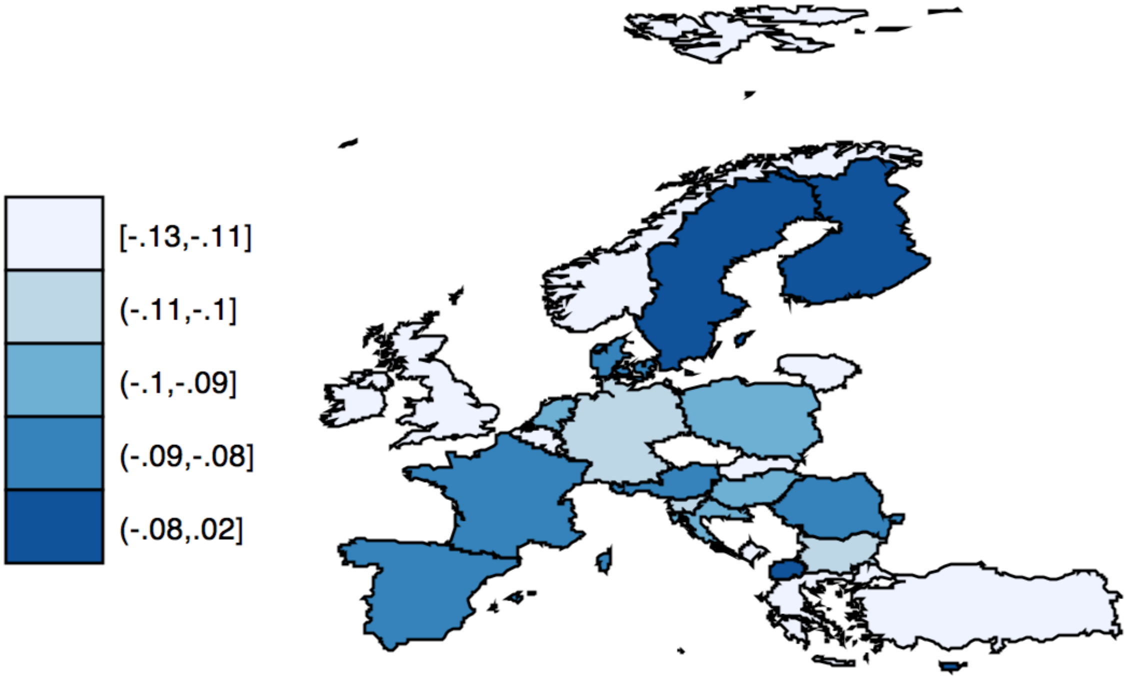
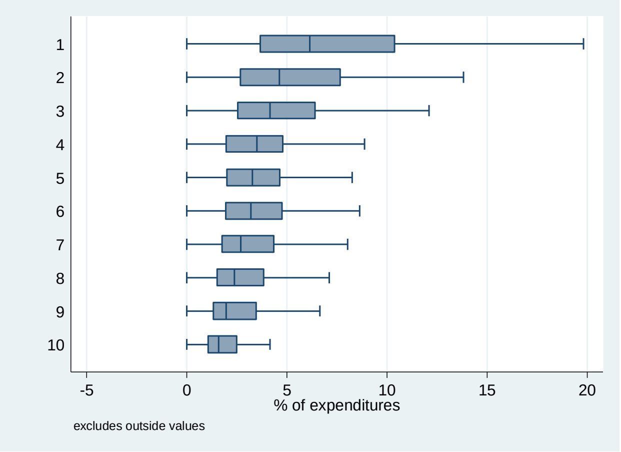
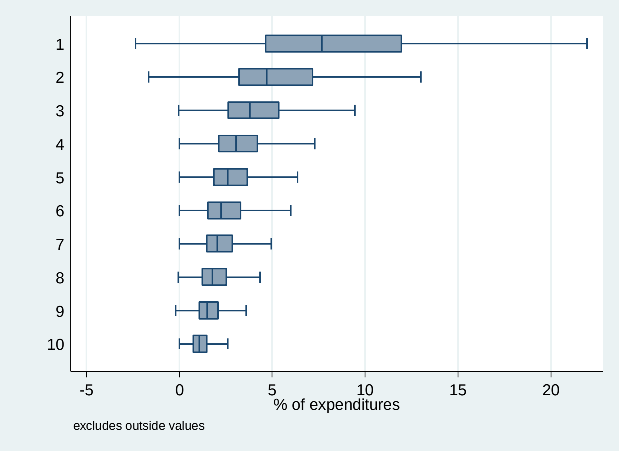


Figure 4: Intra-class variation in electricity and gasoline expenditures by total expenditure decile. *For each decile (1 = poorest, 10 = richest), the blue shaded box shows the interquartile range (IQR) with the median indicated by a line; the whiskers show the range of values within 1.5 times the IQR on either side of the box..*

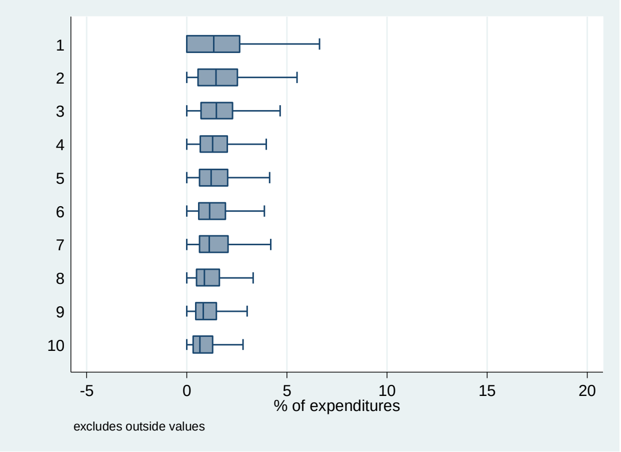
Panel A: Electricity: USA



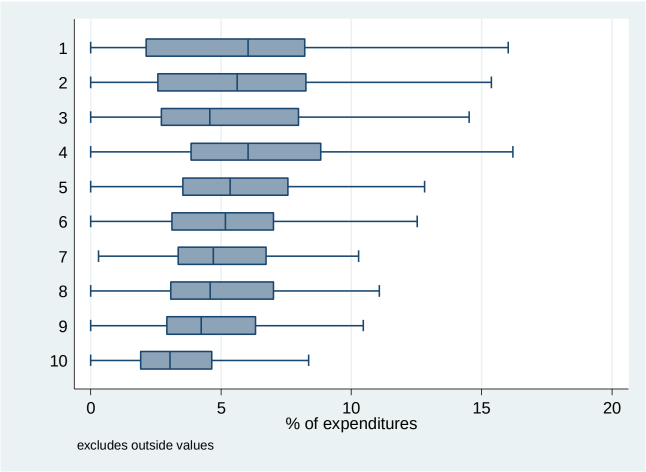
Panel B: Electricity: U.K.



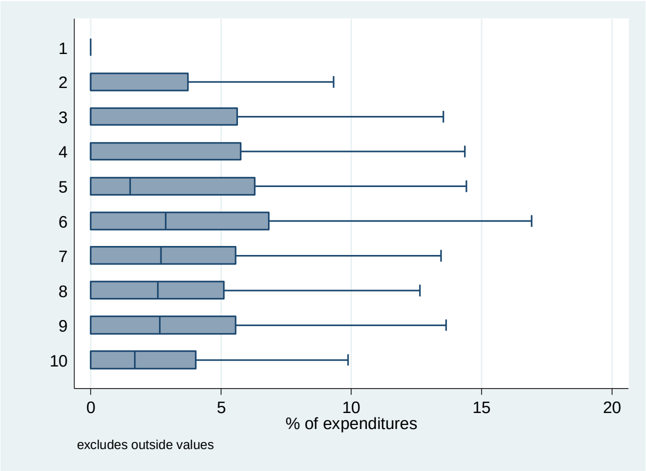
Panel C: Electricity: Mexico



Panel D: Gasoline: USA



Panel E: Gasoline: U.K.



Panel F: Gasoline: Mexico