Don Fullerton

Net Burdens of Carbon Policy Vary within Each Income Group — and within Each Nation*

Most studies of the distributional effects of climate policy are about the "vertical" distribution of burdens up and down the income scale, especially comparing low- and high-income households within the US or Europe. Other studies measure the likely distribution of burdens from global carbon agreements, especially comparing low- and high-income nations.

In contrast, very few studies measure "horizontal" effects within each income group. Domestic climate policy will likely impose greater burdens on families with greater need for heat and air conditioning, compared to other families at the same income level in locations with less temperature variation. For example, Cronin, Fullerton and Sexton (2019) look at costs of a carbon tax reform in the US that has a fairly proportional vertical effect—i.e., reducing real incomes by about 1 percent in all income deciles. Revenue rebates can reduce net burdens proportionally to near zero in all deciles, but revenue-neutral "carbon fee and dividend" also imposes wide disparities within each income group. Within the lowest-income decile, it reduces real net incomes of some households by 2 percent and raises real net incomes of others by 2 percent. Some fraction of low-income households live near the coasts with mild climates that require little spending on heating or air conditioning. Some have no cars and buy no gasoline, in which case, the uniform per capita dividend exceeds their carbon tax burden.

These horizontal redistributions are not a goal of carbon policy, even if they necessarily accompany a plan to discourage carbon emissions. More strongly, however, one might say that horizontal redistributions ought to be avoided. All else being equal, a redistribution that helps one poor person while taking real income away from another equally poor person might be considered unfair. Purely horizontal redistributions reduce some overall measures of social welfare.[1] Policy makers may want to avoid these redistributions, but if so, then they need to know the likely horizontal effects of each proposal at hand. In other words, this issue requires further study.

I will review the Cronin et al. (2019) paper below in order to discuss approaches, data needs, and resulting effects of climate policy across households at the same income level. Their point is that the well-studied vertical redistributions between high- and low-income families are small compared to the under-studied horizontal redistributions. They study costs of a carbon tax, not the distribution of benefits from reduced climate damage—an additional problem that likely adds even more vertical and horizontal impact to heterogeneous households that might gain or lose property value from differential exposure to heat, floods, droughts, storms and wildfires.

Next, I will draw analogies from the large horizontal effects within each income group to discuss the likelihood of large horizontal effects within each country. Studies of redistributions between countries essentially compare effects on the average person in a poor country to the effects on the average person in a wealthy country. But these well-studied vertical effects between countries may pale in comparison to the under-studied horizontal effects across individuals within a country. A reasonable social welfare function accounts for effects on the well-being of individuals, not of institutions or other non-human entities. For these reasons, I end with the suggestion to de-emphasize redistributions between countries and instead focus on people within each country.

THE PROBLEM OF HORIZONTAL REDISTRIBUTIONS

Any policy to reduce greenhouse gas emissions likely raises the price of electricity and gasoline and thus raises costs for those who spend more on energy. Consumer expenditure data from the US and many European countries demonstrate that the average low-income family spends a higher share of income on energy than does the average high-income family. Thus, for vertical distributional effects between high- and low-income families, the conventional view is that carbon policy is regressive.[2] As a consequence, many believe that the additional carbon fee revenue should be used to help cover those extra costs for

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[1] See Pizer and Sexton (2019), Fischer and Pizer (2019), or Hänsel et al. (2021).

[2] Regarding expenditure data, see Flues and Thomas (2015), and Pizer and Sexton (2019). Distributional effects are "proportional" if burdens as a fraction of income are the same for all groups, "regressive" if that fraction is falling with income, and "progressive" if it rises with income.

low-income families.[3] For example, a policy might use carbon fee revenue for equal per capita dividends to all citizens.

Yet, new research in Cronin et al. (2019) disputes this conventional view about vertical distributional effects while bringing new attention to problems from horizontal distributional effects.[4] First, they argue that annual income is not the best way to categorize families from low- to high-incomes. As explained below, they use total annual consumption as a proxy for permanent income, which makes a carbon tax or other policy much less regressive. Second, many countries like the US have automatic indexing (cost-of-living adjustments) for social security benefits and other social transfers to low-income families. When a climate policy raises energy prices, many low-income families then automatically receive higher levels of those public transfers. Tax brackets also are indexed to that price level. Indexing reduces the net revenue from a carbon tax, and it reduces measured regressivity.[5] In fact, they find that the remaining carbon tax burden is overall progressive. Third, households who rely on public transfers that are indexed to the price level do not need as much additional dividend to protect them from harm. Fourth, even if the average carbon tax burden within any income group is offset by this indexing, the burdens within each income group are very heterogeneous.

Heterogeneity of burdens arises both because of different income sources and different expenditure patterns. Within the lowest-income group, for example, burdens are higher for those with large fractions of income from un-indexed wages and those with heavy needs for spending on energy. Indexing of public transfers are based on nationwide average weights for spending categories, so a carbon tax can lead to large net *gains* for other low-income households whose primary income is from indexed social security benefits, whose commutes do not require gasoline, and whose homes are well-insulated. Thus, any package of reforms will create winners and losers within each income group (Sallee 2019).

For a large sample of households, the US Consumer Expenditure Survey (CEX) provides sufficient detail on purchases of various commodities whose prices are differentially affected by a carbon tax. However, it includes neither verified nor detailed information about income sources, taxes paid or transfers received. But Cronin et al. (2019) use the US Treasury Distribution Model (TDM), which includes extensive imputations for constructing a dataset with the necessary heterogeneity across a large, representative sample of families with differing expenditures, sources of income, taxes paid and transfers received.

The TDM starts with a merged file of 300,000 US tax returns plus 22,000 non-filer "information returns" to capture a representative number of those whose income is below the tax filing threshold. It uses only non-dependent returns and weights them, so the final weighted dataset represents 172 million US families. It uses an exact match of the social security number on each return to verify details about social security benefits received and payroll taxes paid. For each tax family, total consumption is computed as taxable income plus fringe benefits minus tax paid and savings. Each return is also matched to a similar family in the CEX whose expenditure shares for 33 consumption categories are applied to total expenditures of the tax family. The TDM makes further imputations for participation in each transfer program and receipts from each program such as Temporary Assistance for Needy Families (TANF), Supplemental Nutrition Assistance Program (SNAP) and the Earned Income Tax Credit (EITC).

Cronin et al. (2019) use the TDM to calculate the effects of a carbon tax with $100 billion of annual revenue, and they employ four alternative assumptions about rebate of revenues: (1) no rebate, but 23 percent of revenue must be used under existing law to index transfers and tax brackets for consumer prices increases; (2) net carbon tax revenue is used for a uniform $229 per capita rebate; (3) net revenue is used for a 5.9 percent increase in all existing transfers; and (4) half of net revenue is used to reduce payroll taxes, and half is used to increase social security benefits.

Burdens are determined for each family by using an input-output model to calculate the direct and indirect impacts of this carbon tax on prices for each of 389 consumer goods. Thus, the tax impacts the price of fuels and intermediate goods according to their carbon intensities, and these changes impact the market price of each commodity.[6] The overall consumer price index rises about 1 percent, but the price increase for electricity is 9.0 percent, natural gas is 14.8 percent and gasoline is 14.8 percent. The price hike for mass transit is 4.6 percent and airline tickets is 5.5 percent.

Their paper also discusses various limitations. First, they do not measure the efficiency effects of a carbon tax but instead calculate detailed distributional effects, assuming no changes in behavior. Second, they ignore possible changes in factor prices. They focus on diverse patterns of spending on energy-intensive goods and of transfers received. Third, they have one year's cross-section of data on consumer spending and transfer receipts, not a panel to construct a long-term measure of well-being. Annual income is a poor measure of well-being, because

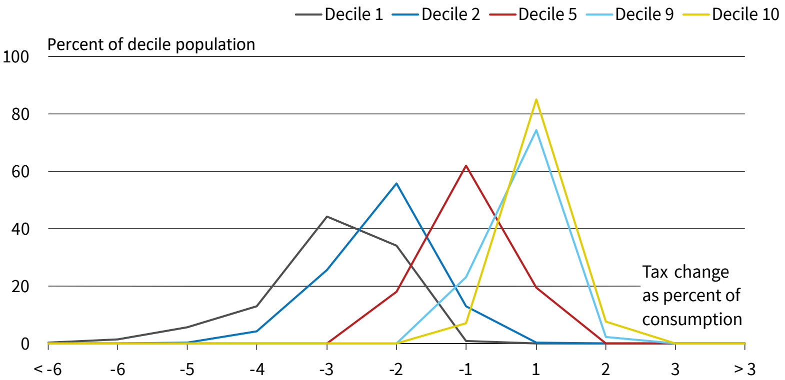
[3] Papers that find the carbon tax to be regressive and that suggest rebates to help low-income families include Blonz et al. (2011), Dinan (2012), Grainger and Kolstad (2010), Hassett et al. (2009), and Mathur and Morris (2014).

[4] Following Cronin et al. (2019), similar studies of horizontal effects are in Douenne (2020) for France and in Hänsel et al. (2021) for Germany.

[5] Dinan (2012) and Fullerton et al. (2012) account for indexing of transfers but not for income tax brackets.

[6] Each family's added burden is calculated as their observed expenditure on each consumption good times the price increase for that good, so quantities are fixed. Similar methods are employed in Metcalf (2009), Grainger and Kolstad (2010), or Mathur and Morris (2014).

Figure 1
Net Tax Changes by Decile for Carbon Tax with Per Capita Rebate



Source: Cronin et al. (2019). © ifo Institute

the low-annual-income group includes not only the perennially poor but also the young who earn more later, the elderly who earned more earlier, and those with volatile income observed in a bad year. Instead, they use annual spending to account for consumption smoothing.[7] Annual consumption is not a perfect measure of permanent income, because of borrowing constraints and information problems, but it is better than annual income as a measure of family well-being. Fourth, the merged dataset excludes information on each family's geographic location, house characteristics, appliance energy efficiency, or commuting distances—all of which affect exposure to carbon tax burdens. It does capture the variation of actual energy spending across households.

RESULTS FOR US HOUSEHOLDS

Cronin et al. (2019) show the sensitivity of results based on different assumptions. As with prior studies, the use of annual income with no indexing means the carbon tax is regressive. When they instead use annual consumption to classify families, the carbon tax is roughly proportional. Then, when they account for indexing, they find that the carbon tax is progressive. The burden rises from 0.45 percent of consumption for the lowest consumption decile to 0.80 percent of consumption for the highest decile. Some families have little need for energy and thus have a very small carbon tax burden but still receive increased transfers that reflect the nationwide average increase in costs of consumer goods. Within the first decile, even with no dividend, this carbon tax leads to a net gain for 13.6 percent of families.

When carbon tax revenues are refunded by a lump-sum per capita dividend, the net additional burden as a percent of consumption is even more clearly progressive. The poorest ten percent of families gains 2.6 percent of consumption on average, and each of the first seven deciles receives a net gain, but the richest decile faces a net tax burden equal to 0.58 percent of consumption. This progressivity appears in Figure 1, where the gray line shows that burdens within the poorest group are negative, while the yellow line shows that the distribution of burdens for the richest group is mostly positive.[8]

The three mechanisms for rebate revenues cause larger horizontal redistributions than those imposed by the carbon tax itself. Figure 1 shows effects of the per capita rebate. Family size varies within each decile, and so per capita rebates vary as a percent of income. Within the poorest decile, 7 percent receive net tax cuts of more than 4 percent of consumption, while 0.01 percent bear a positive net burden. In the highest decile, 85 percent get a positive net burden up to 1 percent of consumption. While the average burden in the richest decile is 0.58 percent of consumption, 8 percent of them face extra burdens up to 2 percent of consumption, and 7 percent *gain* up to 1 percent of consumption.

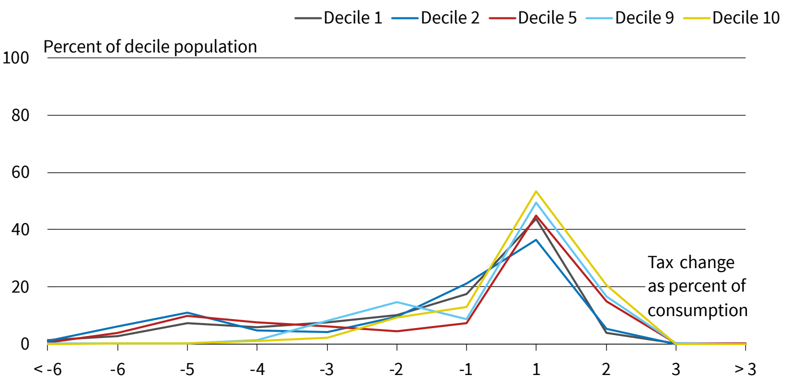
Next, consider the case of a uniform 5.9 percent increases in all public transfers to return all net carbon tax revenue (above and beyond the automatic indexing of transfers). This reform also results in a progressive distribution of average burdens across the ten deciles (but it is less progressive than with the per capita rebate). The poorest group gains 0.96 percent of consumption on average, and all of the first eight deciles gain, but the top decile loses 0.50 percent of consumption.

Again, however, focusing on vertical distributions by looking at the average family in each decile completely misses the bigger story. Within the poorest decile, the average gain is 0.96 percent of consumption, but 47 percent of families get a net tax increase. Complicated rules for public transfers deny eligibility to some people, and even those who are eligible often do not participate. Only 32 percent of families in the

[7] See Poterba (1989), or the permanent income hypothesis of Friedman (1957). Declining marginal utility of consumption within a year means that households wish to smooth consumption over time to reflect their permanent income. Thus, carbon tax regressivity is exaggerated when using annual income to classify households.

[8] Figure 1 here is taken from Figure 1A in Cronin et al. (2019), while Figure 2 below is taken from their Figure 1B. Each curve represents a selected decile (lowest, second, fifth, ninth, and tenth). The height of each curve shows the percent of that selected decile facing the net burden (as a percent of consumption) on the horizontal axis.

Figure 2
Net Tax Changes by Decile for Carbon Tax with 5.9% More Transfers



Source: Cronin et al. (2019). © ifo Institute lowest decile receive EITC benefits, only 19 percent receive SNAP benefits, and only 16 percent receive social security income. Thus, a proportional increase in such transfers adds more horizontal variation than does the carbon tax itself. Within each of the deciles shown in Figure 2, even where the *average* family gains up to 1 percent of consumption, net losses are experienced by 42 percent to 66 percent of families. Some of those losses exceed 2 percent or 3 percent of consumption. The figure shows more variation in net burden under the transfer expansion than under the per capita rebate.

This disconcerting picture raises the question of whether a carbon tax reform package can be designed to reduce horizontal disparities within each income group. Available data include each family's expenditures and income sources, but not the age or insulation of their dwelling nor the energy efficiency of their appliances and vehicles. It might be hard for any policy package to account for each family's weather, commuting distance, or access to commuter rail. While carbon tax rebates based upon these characteristics could reduce horizontal variation in net burden outcomes, however, the big problem is that such rebates also affect incentives and could reduce future investments in energy efficiency or insulation. Ideally, revenue could be used for a one-time transfer to families based on age, location, home size and vehicle vintage. Such a payment would be extremely difficult to implement in practice, however, and many people may believe that heavy energy users ought to pay for it.

The main point here, however, is that this analysis of horizontal redistributions could be extended to a hundred nations participating in the Paris Agreement to reduce emissions. The US is not likely to implement carbon pricing soon, but 40 countries and 20 subnational governments already price carbon (World Bank 2016). Policymakers elsewhere need information about both vertical and horizontal redistributions from a carbon tax, and they need to recognize that heterogeneity can complicate efforts to return carbon tax revenues via existing transfers in ways that do not increase disparity of tax changes within each income group.

REDISTRIBUTIONS BETWEEN LOW- AND HIGH-INCOME COUNTRIES

Just as studies of vertical effects from domestic carbon policy look at redistribution between high- and low-income groups, other studies of vertical effects from worldwide carbon policy look at redistribution across high- and low-income countries. This section reviews results from some of these global studies—despite their dubious equity implications. Theories of economic justice-based moral philosophy account for the welfare of human individuals, not the welfare of non-human entities such as institutions, corporations or nations. Rather, the general interest in these results is probably attributable partly to simple nationalism, partly to the belief that rich and poor countries are adequate representations of rich and poor individuals, and partly to the valid need for inputs to political economy models of diplomacy. Indeed, these results can affect international agreements on emission reductions.[9]

This section also points out global analogies to the research on horizontal redistributions described above. Just as the under-studied horizontal redistributions within each income group are shown above to swamp the vertical redistributions from a nation's domestic carbon policy, the under-studied horizontal redistributions within a country can swamp the vertical redistributions from a worldwide carbon policy.

Initially, Nordhaus and Yang (1996) study worldwide redistributions using the Regional Integrated Climate and Economy (RICE) model, dividing the world into ten regions.[10] They compare the con-cooperative solution to a cooperative solution (the efficient equilibrium path). The US and Former Soviet Union (FSU) lose from this efficient carbon policy, but the rest of the world reaps major net benefits "because the mitigation efforts are undertaken primarily in the high-income countries early in time while the major benefits in terms of damage avoided accrue to the developing countries in several decades" (Nordhaus and Yang 1996, 756).

Similarly, Mendelsohn et al. (2006) measure the damage that could be avoided by implementing global climate policy. Because *marginal* climate damage to agriculture are increasing in temperature, and because the poorest nations are located in low latitudes with already-high temperatures, they find that the "poorest half of the world's nations suffer the bulk of the damage from climate change, whereas the wealthiest quarter has almost no net impacts" (Mendelsohn et al. 2006, 161). In their recent review article, Hsiang et al. (2019) summarize many other estimates of differential climate effects across nations, not only through changes in temperatures but also through changes in rainfall, cyclones and tornadoes. They find that the distributions of these physical changes have no clear associations with current incomes, but poor nations have greater marginal damage from those same changes. In other words, similar physical changes are likely to impose greater damage on low-income nations.

The consensus from this brief review so far is that an efficient climate policy such as a uniform worldwide carbon tax would likely have progressive damage reduction effects, providing the most help to poor nations that would otherwise suffer the most damage. Cronin et al. (2019) and others focus on the distribu-

[9] For examples related to international climate negotiations, see Lange et al. (2010), and Bretschger (2013).

[10] Their ten regions are listed as: the US, Japan, China, European Union, former Soviet Union (FSU), India, plus Brazil/Indonesia, 11 other large countries, 38 medium-sized countries, and finally, 137 small countries.

tion of the burdens from a carbon tax through raised output prices (ignoring changes in factor prices). At the global level, Ward et al. (2019) undertake similar calculations of burdens by mapping international supply chains and using input-output tables to estimate the effects of a worldwide carbon tax on each country's output prices. Overall costs rise the most in countries with large sectors that are carbon-intensive, especially developing or transitioning economies such as China, India and Russia. A global carbon tax would reduce costs for industrialized countries with efficient production technologies and especially those with low-carbon energy systems, such as Brazil with hydro power or France with nuclear power.

Thus, ignoring factor price changes, a global carbon tax may have regressive effects between countries on the cost side but progressive effects across countries due to the benefits of reduced climate damage. However, the point here is that none of these studies deals with heterogeneity within countries or horizontal redistribution.

One partial exception is a new working paper by Sager (2021). He uses a trade gravity approach to estimate a single worldwide system of demands and supplies, using data on trade in final goods from 35 sectors across 40 countries in the World Input-Output Database. Estimated demands are not homothetic, so spending shares depend on income (both within each nation and across nations). Costs of a global carbon tax within each country depend on emissions intensity. He finds that effects are mildly regressive within industrialized countries, mildly progressive within developing countries, and quite regressive across countries. As in other studies, he finds that the use of carbon tax revenue within each country can swamp those effects. Thus, depending on the use of revenue, any carbon tax can have progressive or regressive burdens.

DISCUSSION

While Sager (2021) looks both across countries and within countries, the effects he considers within each country are vertical redistributions between income groups – not horizontal redistributions. The point in Cronin et al. (2019) reviewed above is that a carbon tax can have large and capricious effects across families at the same income level, because some families need more use of carbon-intensive goods for commuting, heat, or air conditioning. Those families invested in their houses and locations long ago, so any new carbon policy could impose large losses in house values – losses that cannot be avoided by moving away or by paying to insulate their homes. Some individuals also face psychological costs of sudden job loss and the cultural shock of adjusting to new technologies.

Similarly, those families have widely differing benefits from a climate policy that reduces damage, having invested long ago in locations that have large or small benefits due to reductions in storm damage, drought, or sea-level rise. In some countries, some families may gain from global warming.

Nobody has estimated horizontal effects within each nation based on a global climate policy that yields differential costs and also differential benefits at the same income level. Such a study would be difficult, especially since each household's costs come earlier than their benefits from reduced climate damage. The damage is also random, so valuation depends on risk aversion. Those effects may or may not be deemed unfair in a social welfare function, but policymakers may value studies on those effects in order to make informed decisions about policy. Such studies would not be easy because they would require much data on many diverse families in order to capture heterogeneity by location characteristics and family characteristics.

In fact, country studies other than Sager (2021) do not really capture the intended measurement of vertical effects either, simply because high-income countries include many low-income families, and low-income countries include many high-income families. Heterogeneity within each country means that comparing high- and low-income countries misses not only horizontal redistributions within the same income group, but it also misses the actual vertical effects of a global climate policy on high-income people compared to low-income people.

Finally, this thought raises the same question about other studies that try to use aggregated data to measure distributional effects. When individual household data are not available, many researchers use average income for each postal code or each county (or each state or province). Perhaps a small neighborhood is relatively homogeneous, so that measuring gains or losses for each rich or poor neighborhood provides some information about redistributions between rich and poor households. But still, the individual household is the unit of interest. A social welfare function cares not about the gains or losses to a neighborhood per se, but to people.

This problem worsens at higher levels of aggregation. Despite substantial differences in average county incomes across counties in the US, any US county has wide internal disparities between rich and poor. So, measuring redistributions between rich and poor counties in the US might say very little about what happens to rich and poor US households. Then, on a grander scale, any measured redistribution between rich and poor nations says precious little about the change in any measure of social welfare that is a function of the diverse incomes of individual households, especially since any redistribution of funds from rich countries to poor countries is so often commandeered by the rich and powerful individuals within poor countries.

The implications of this line of reasoning are manifold. First, we need more studies on redistribution among the many different households within each nation, and we need such studies for more nations. Second, we need careful consideration of the horizontal redistributions within each low-income country, and within each high-income country, what these effects imply for alternative measures of social welfare, and what it means in terms of how policymakers can change their proposal to reduce those capricious horizontal redistributions (for any given carbon reduction and for any desired vertical redistribution). Third, studies that must use county or other small jurisdictions as the unit of observation need not just be circumspect about the missing heterogeneity within each jurisdiction, but also exhibit some effort in dealing with the missing measures of horizontal redistribution.

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