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ABSTRACT

This paper examines, individually and jointly, an excise tax on carbon and an expansion of EITC benefits to childless workers. We estimate how an illustrative tax of $32 per ton of CO_2 from fossil fuel combustion would burden households differentially across the income distribution, how it could affect worker benefits from the existing EITC program by lowering wages, the share of the revenue that would be necessary to fund an EITC expansion to childless workers, and the further resources policymakers would need to target to low income households to hold them unburdened on average from a carbon tax. We find that although in principle a carbon tax that lowers wages could affect EITC benefits and thus impact low-to-moderate income households, the likely magnitude of the effects is very small. We find that far more important to the distribution of burden is the extent to which the carbon tax passes through to raise retail prices, a decidedly regressive outcome, versus lowering wages, which is distributionally much more neutral. Using emissions and other data from 2013 and 2014, we also find that the revenue from the carbon tax could be enough to expand the EITC to childless workers and hold other low income households harmless, combining a regressive tax with progressive benefits. We find that such a policy package could create net benefits for on average for the lowest income deciles while improving incentives to work and providing environmental benefits.

Keywords: Carbon tax, tax swap, EITC, distributional issues

1. INTRODUCTION

Economists have long argued that a price on carbon, such as through a carbon tax, is a critical component of efforts to stabilize greenhouse gases (GHGs) in the atmosphere. One concern about the policy, however, is its negative effect on low income households, both in absolute terms and relative to higher income households. A carbon tax would be regressive because lower income households tend to spend a higher percentage of their income on energy and other goods whose relative prices will increase under a carbon tax. A number of analysts have noted that policymakers could target some of the revenue to benefit low income households so that on average they bear no net burden from the tax.

Recent proposals in the United States, such as Stone (2015), call for channeling carbon tax revenues to low income households through a portfolio of existing social safety net programs, including refundable tax credits like the Earned Income Tax Credit (EITC). Households that file a federal tax return could receive tax credits in an amount on par with an estimate of the burden they bear from the carbon tax. Stone (2015) suggests that this approach, along with supplements to social security payments and state-run food stamp benefits for non-filers, could ensure that about 95 percent of households with incomes below 150 percent of poverty levels would be no worse off under a carbon tax than they would be without it.[1]

Entirely independent of the context of the carbon tax, policy advocates have called for the expansion of the EITC to boost the income of childless workers, married or single. Members of both political parties support the expansion to childless workers.[2] Progressives like the additional income support for low-income workers and conservatives like the work incentive that comes with an EITC benefit. But without an obvious way to pay for the benefits, the potentially bipartisan proposal has stalled. Thus the question arises how policymakers might combine a carbon tax and an EITC expansion, pairing a regressive tax with progressive benefits.

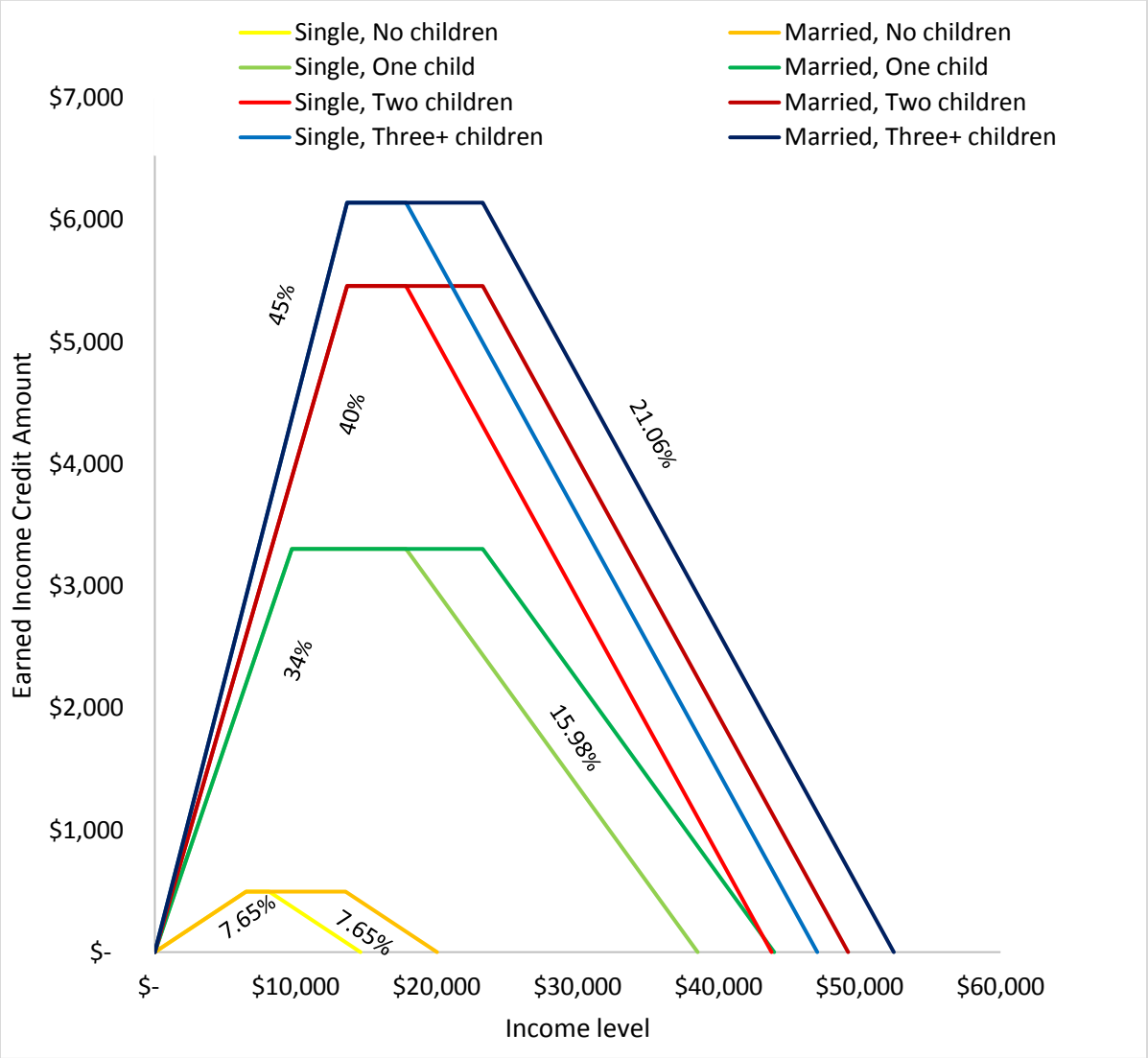
Background on the EITC

The EITC is a tax credit program that provides money to low- and moderate-income working people in proportion to their earned income. The EITC is fully refundable, meaning that the credit is available to eligible participants whether they owe income taxes or not. It is one of the largest anti-poverty programs in the United States, and the largest such program implemented through the tax system. Its effects are concentrated on those whose income (after taxes and transfers) would otherwise be 75 percent to 150 percent of the poverty line.[3] The benefits automatically adjust for inflation each year.

[1] This does not account for environmental outcomes or other provisions of a carbon tax package.
[2] Marr (2015)
[3] Hoynes and Patel (2015)

The EITC is widely viewed as effective in encouraging work and alleviating poverty. Using the 2015 Census supplemental poverty measure, Short (2015) shows that income from refundable tax credits (primarily the EITC) reduces the total number of people in poverty by 16 percent and the number of children in poverty by nearly 30 percent. In addition to reducing poverty and unlike other means-tested transfers, the EITC is designed to incentivize work. Research has shown that the incentive effects of the program have led to an increase in labor force participation for single mothers.[4] In addition, the EITC results in academic benefits for the children[5] and health benefits for the parent and child.[6] Figure 1 shows the benefit structure in 2014 by household demographics and wage income.[7]

Figure 1. EITC Benefits by Household Demographics and Wage Income, 2014



[4] Eissa and Liebman (1996); Meyer and Rosenbaum (2001)
[5] See Chetty et al (2011); Dahl and Lochner (2012); Michelmore (2013); Miller and Zhang (2009)
[6] See Averett and Wang (2012); Cowan and Tefft (2012); Evans and Garthwaite (2014); Hoynes et al. (2015)
[7] More information appears at the IRS website: https://www.irs.gov/credits-deductions/individuals/earned-income-tax-credit/eitc-income-limits-maximum-credit-amounts-1-year.

The sloping lines in Figure 1 indicate that if households are in the phase-in range of the program, they receive as much as 45 cents of EITC benefits for each incremental dollar they earn, depending upon their household demographics. In contrast, in the phase-out range of the program, they lose 21 cents in EITC benefits with each additional dollar they earn. The numbers in the graph marked with percentages show the phase-in and phase-out percentages that apply for different household types.

For example, the EITC for married couples with two children is phased in at a 40 percent rate on the first $13,650 of earned income, yielding a maximum credit of $5,460. The credit begins to phase out at a 21.06 percent rate when earned income exceeded $23,260, with the credit fully removed when earnings reached $49,186. The maximum credit is $6,143 for families with three or more qualifying children, $3,305 for families with one child, and $496 for individuals with no children.[8]

To illustrate the distribution of EITC benefits in aggregate across households by income (pre-credit), Table 1 presents IRS Statistics of Income data for 2012.[9]

Table 1: EITC Benefits for Families with Children, 2012

Adjusted Gross Income Bracket ($ thousands)	Number of Tax Returns (millions)	Earned Income Tax Credit, refundable portion ($ billions)	Earned Income Tax Credit used to offset income tax and other taxes ($ billions)
< 5	10.4	$1.14	$0.18
5-10	12.0	$6.70	$1.14
10-15	12.6	$13.19	$2.04
15-20	11.6	$14.14	$1.45
20-25	10.2	$9.40	$0.95
25-30	8.7	$6.07	$0.81
30-40	14.5	$4.74	$1.12
40-50	10.9	$0.64	$0.18
50-75	19.0	$0.11	$0.04
75-100	12.1	$0.00	$0.00
> 100	20.9	$0.00	$0.00
Total	142.8	$56.01	$7.86

[8] Under section 32(b)(3), the larger credit amounts for families with three or more children are scheduled to expire at the end of 2017.

[9] The data are available at http://www.irs.gov/uac/SOI-Tax-Stats---Individual-Statistical-Tables-by-Size-of-Adjusted-Gross-Income.

As shown in Table 1, in 2012, the EITC program disbursed $56 billion as a refundable credit to families. A smaller amount, $7.9 billion, offset their income tax liability as well as other taxes. The overall benefits were largest for families earning between $10,000 and $20,000 annually. Because the EITC phases out at higher income levels, families earning above $75,000 did not receive any benefits.

The incidence of a carbon tax and its intersections with the EITC

As Mathur and Morris (2014) review, the final economic incidence of a carbon tax depends heavily on what happens to the revenue. The most efficient form of revenue recycling would offset the most distortionary taxes, meaning the ones that have the highest marginal deadweight loss. The most progressive approach would target the revenue more heavily to lower income households, who bear little of the existing tax burden.[10] Thus, to help policymakers strike the tradeoff between the most efficient approach and concerns for low income households, it is useful to understand just how much revenue would be necessary to hold low income households harmless on average and how to revise existing benefit programs to channel the revenue appropriately.

The carbon tax/tax credit connection could be more complicated than the literature has so far recognized. A carbon tax can lower wage income as well as increase consumer costs. That means that the full incidence of the tax on low- to moderate-income households depends on how it affects their EITC benefits, which are a function of wage income. Moreover, in principle, any efforts to ensure that a redistribution program reliably holds poor households harmless from a carbon tax should take into account the potential effects on their social safety net benefits. The question is whether the carbon tax's effect on EITC benefits is likely to be large enough to worry about.

To find out, we model an illustrative $32 per metric ton tax on CO_2 emissions from fossil fuel combustion (a carbon tax, for short) and see how it affects households of different incomes, including via the effects on EITC payments, not accounting for how households and businesses may change their activities as a result of the tax. We estimate these potential outcomes under different assumptions about how the carbon tax incidence passes through to households via higher prices in their consumption bundles and lower labor income. Departing from earlier studies such as Metcalf, Mathur and Hassett (2009), we ignore the potential incidence of a carbon tax via capital income, both because changes in capital income are unlikely to impact EITC payments (which are based on earned labor income) and because capital income is a small fraction of overall income for low income households.

[10] A review of this literature appears in Parry and Williams (2011). Also see Goulder et al. (1999), Parry et al. (1999), Parry and Oates (2000), Parry and Bento (2000), and CBO (2007).

We model, individually and jointly, the carbon excise tax and an expansion of EITC benefits to childless workers. We estimate how the tax would burden households differentially across the income distribution, how it could affect worker benefits from the existing EITC program by lowering wages, the expenditures necessary to fund an EITC expansion to childless workers, and the resources policymakers would need to target to low income households to hold them unburdened on average from a carbon tax, taking into account the benefits of EITC expansion. We find that although in principle a carbon tax that lowers wages could affect EITC benefits and thus impact low-to-moderate income households, the likely magnitude of the effects is very small. We find that far more important to the distribution of burden is the extent to which the carbon tax passes through to raise retail prices, a decidedly regressive outcome, versus lowering wages, which is distributionally much more neutral.

The paper proceeds as follows. In Section 2, we discuss our methodology, carbon tax policy scenarios, and data. Section 3 reports the estimated burdens of the carbon tax by income class and household characteristics. It includes a sensitivity analysis around the assumption of the shares of the carbon tax passed through to households via consumption and wages. Section 4 models the potential expansion of the EITC to childless workers and calculates how much carbon tax burden the EITC expansion could offset. It breaks down the remaining burden by household characteristics. Section 5 concludes.

2. METHODOLOGY

Our basic methodology follows that in Mathur and Morris (2014). In this study, we use more recent data, make different assumptions, and investigate different policy scenarios. As in Mathur and Morris (2014), we model a tax that is levied on the carbon content of coal at the mine mouth, natural gas at the well head, and on petroleum products at the refinery. Imported fossil fuels are also subject to the tax. We assume that the tax burden is fully passed forward to households in the form of a combination of higher prices of goods and services and lower wages, and we examine the sensitivity of the results to different combinations of burdens on the uses and sources of income.

In our methodology, we start with a carbon tax of $32 per metric ton of CO_2 emitted from fossil fuel combustion. The tax would have generated about $167 billion in gross revenue 2013, ignoring short run reductions in emissions as a result of the tax and effects on revenues from other tax instruments.[11] We apportion the estimated revenue across the oil, natural gas, and

[11] EIA (2015) and EPA (2016) estimate 2013 emissions from U.S. fossil fuel combustion were 5,355 and 5,157 million metric tons, respectively. For comparison, the Congressional Budget Office (CBO) analyzed a GHG tax that starts at $25 per metric ton on most GHG emissions (not just fossil fuel-related CO_2) in the United States and increases at an annual real rate of 2 percent.[11] CBO estimates that in the first full fiscal year of implementation the tax would raise $90.3 billion in net revenue, accounting for the tax's effect on emissions and its general equilibrium effects on revenues from other

coal combusted in the United States in proportion to each fuel's emissions in the U.S. inventory of CO_2 emissions from those fuels in 2013.[12]

We start with input-output matrices from the U.S. Bureau of Economic Analysis (BEA) called the Summary Make and Use matrices from 2013. The Make matrix shows how much each industry makes of each commodity, and the Use matrix shows how much each industry uses of each commodity. Using these two matrices, we derive an industry-by-industry transactions matrix that traces the use of inputs by one of 66 industries to all the other industries. Using various adding-up identities and making assumptions about production and trade, we can trace the impact of price changes from the carbon tax in one industry to the products of all other industries in the economy. We translate those price increases into corresponding price increases for these consumer items using the Personal Consumption Expenditure Bridge tables, also from BEA. Then, we use household level expenditure data from the U.S. Bureau of Labor Statistics' Consumer Expenditure Survey (CEX) for 2014 to compute the carbon taxes paid (via those higher prices) by each household in the survey across 33 categories of personal consumption items.

We use the household as our unit of observation consistent with our goal in these policy scenarios to identify approaches that preserve individuals' buying power in the context of their household. Taxes on energy can be passed forward into higher consumer prices or backward in the form of lower returns to factors of supply (capital, labor, and resource owners). A number of large-scale general equilibrium models (CGE models) suggest that in the short to medium run, the burden of a carbon tax will be mostly passed forward into higher consumer prices, but our approach also allows some of the burden to fall on workers.[13]

We make several important assumptions. First, we assume no consumer behavioral response to the after-tax prices, meaning that our analysis reflects the before-tax consumption patterns. One can think of this as an instantaneous incidence analysis, consistent with low short-run elasticities. We also abstract from ways in which the average incidence by income decile may obscure important variations within those income categories. For example, we do not examine potentially significant intra-decile variations in consumption, and we ignore regional disparities in the distribution of carbon tax burdens, consistent with research that shows that differences in consumption bundles of energy-intensive goods tend to even out the impact of the price on carbon across the country.[14]

Finally, our incidence analysis focuses on the gross burden of the carbon tax itself, with attention to linkages with the EITC program. That means that we do not account for several

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instruments. During the first decade the tax in in effect, CBO projects that cumulative emissions from sources subject to the tax would fall by roughly 9 percent.

[12] A tax at the same rate that covers more of the U.S. GHG inventory would result in both greater overall tax burdens and greater environmental benefits.

[13] See, for example, Bovenberg and Goulder (2001) and Metcalf et al. (2008).

[14] Hassett et al (2009)

outcomes of our policy scenarios that could affect (positively or negatively) the incidence of the policy on low to moderate income households. For example, the carbon tax could lower incentives to work by reducing the after-tax real wage, while an expansion of the EITC may increase incentives to work. Also outside this analysis are the revenue effects and second-order distributional outcomes from ways in which a carbon tax lowers the revenues from other tax instruments, such as income and payroll taxes.[15] Also, we do not estimate how higher real prices affect baseline government spending, such as on higher energy costs, and how the price indexing of certain social safety net payments could buffer the impact of a carbon tax on poor households and social security recipients.

And we do not account for other changes that could coincide with the policy scenarios and affect household welfare, environmental benefits, general equilibrium effects, changes in regulatory programs, and state-level policy and revenue changes. Although the incidence estimates reported here do not take account of the full range of economic and fiscal outcomes of the tax, our results are a reasonable first approximation of the short run welfare impacts of a carbon tax.

Carbon Tax Policy Scenarios

To the extent it is passed on to workers through lower wages, a carbon tax could consequently affect households' EITC benefits. In the four scenarios we develop for this analysis, we assume the entire burden of the carbon tax falls on households via higher retail prices and lower wages; the tax has no effect on capital income. The tax is $32 per ton of CO_2 and applies to the carbon in fossil fuels, raising $167 billion in gross revenue.

All of the scenarios involve the same tax rate and revenue. The only differences across scenarios are in our assumptions about how the tax is passed through to consumption and wages, and whether or not we account for how the carbon tax affects EITC benefits.

The four carbon tax scenarios are as follows:

1) Assume all of the carbon tax passes through to prices paid by households, i.e. all the burden falls on consumption.
2) Assume the burden is split across the uses and sources of income: 80 percent falls on consumption, and 20 percent falls on wages.
3) Same as #2, but account for how the carbon tax affects EITC benefits.
4) (Sensitivity Analysis) Repeat the analysis above in Scenarios 2 and 3, but assume the burden is split such that 20 percent falls on consumption and 80 percent falls on wages.

[15] To analyze excise tax changes, CBO, the Joint Committee on Taxation, and U.S. Treasury incorporate revenue offsets of about 25 percent. See JCT(2011), JCT(2016), and Horowitz et al. (2017).

We first sort households by annual income (before the carbon tax) into ten groups, or deciles, from the ten percent of households with the lowest income to the ten percent with the highest income, and then calculate the burdens each group bears. [16]

Importantly, we do not model the use of the revenue, so these numbers represent the *gross* burden before any rebates, tax cuts, or other disposition of the revenue.

3. THE EFFECTS OF A CARBON TAX ON EITC BENEFITS

Scenario One: Entire carbon tax burden falls on consumption

This scenario reprises results that are familiar in the carbon tax literature. Table 2 below presents the estimated burden of the hypothesized 2014 carbon tax across households (not accounting for how the revenue is used), assuming the entire burden passes through via higher retail prices. The entries show the resulting average carbon tax burden as a fraction of income for households in each income decile. Confirming earlier studies of carbon tax incidence as a share of income,[17] we find the carbon tax is regressive across the entire income distribution.[18] The burden in the lowest income decile is over five times the burden in the top decile when measured as a fraction of annual income.[19]

[16]Pechman (1985) realized that income data for the low income groups suffered from substantial income mismeasurement. Since then, the approach adopted by him and several others, including in this paper, is to discard the bottom half of the lowest decile, i.e. only look at the top half of households in the bottom decile, rather than the entire decile.

[17] Mathur and Morris (2014), Hassett, Mathur and Metcalf (2009), Marron and Toder (2013), Dinan and Lim Rogers (2002), Dinan (2012) and Rausch and Reilly (2012)

[18] These results are similar to Hassett et al (2009), but we do not model the electricity sector separately. They found that the total burden in the lowest decile was over four times the burden at the top in 2003 when measured using income. The direct burden was more than five times higher in the lower deciles relative to the top, while the indirect burden was more than three times higher. As shown in Table 1, the use of more recent 2014 data suggests that the burden today would be much higher on the lower income deciles relative to the top—more than five times higher for the total burden, nearly seven times higher for the direct burden and more than 3.7 times higher for the indirect burden.

[19] The actual burden on each decile in dollars appears below.

Table 2. Carbon Tax Burden by Annual Household Income: All Burden on Consumption

Decile	Direct (%)	Indirect (%)	Total (%)
Bottom	1.135	0.936	2.071
Second	0.849	0.625	1.475
Third	0.634	0.481	1.114
Fourth	0.502	0.388	0.890
Fifth	0.450	0.366	0.816
Sixth	0.342	0.289	0.631
Seventh	0.347	0.298	0.645
Eighth	0.276	0.283	0.559
Ninth	0.258	0.247	0.505
Top	0.155	0.211	0.366

Source: Authors' calculations. The table reports the within-decile average ratio of carbon tax burdens to income.

Table 2 also shows the burden of the direct and indirect components of the tax. The direct component measures household burdens from their consumption of energy, such as gasoline, home heating and electricity. The indirect component measures the increase in prices of all other goods as a result of the higher after-tax fuel costs. The direct component of the tax is highly regressive – the average tax burden in the bottom decile is 7 times the average burden in the highest decile in 2014. The regressivity of the indirect portion of the tax is slightly above half of the direct component.

Table 3 shows the average dollar burden of the tax and the average income across income deciles. The average dollar tax burden is higher for higher income households because their consumption on average is higher than for low-income households; it is four times higher for the top decile than the bottom decile.

Table 3. Carbon Tax Burden and Annual Household Income by Income Decile: All Burden on Consumption

Decile	Average Carbon Tax Burden ($)	Income ($)	Aggregate Burden ($ Billions)
Bottom	205.70	10,194.33	3.95
Second	249.63	17,215.98	9.58
Third	293.59	26,336.81	11.24
Fourth	322.33	36,240.72	12.38
Fifth	388.62	47,955.68	14.91
Sixth	381.62	60,638.29	14.63
Seventh	495.79	76,417.08	19.06
Eighth	540.91	96,894.76	20.73
Ninth	640.36	127,398.06	24.59
Top	832.22	236,442.11	31.96

Aggregating the burden across the bottom two deciles, our results suggest that the total burden on these low income households is $13.5 billion.[20] Therefore, assuming full pass through of the tax to consumption, about 8 percent of the gross carbon tax revenue could hold these households harmless on average.[21]

Scenario Two: When the carbon tax lowers wages as well as raising prices

Next we assume that some of the carbon tax burden is passed to workers in the form of lower wages. We assume that 80 percent of the tax is passed forward to consumers as higher prices and 20 percent falls on workers in the form of lower wages.[22] This is the approach taken in Metcalf, Mathur and Hassett (2012) to offer a range of possible distributional outcomes.

We begin by reviewing in Table 4 the initial distribution of 2014 wage income in the CEX data. The data only include wage and salary income, excluding all capital income sources such as rents, interest and dividends.

[20] Note that when we aggregate across households, we continue to drop the bottom 5% of households.
[21] As shown in Mathur and Morris (2014), the incidence of a carbon tax varies significantly within income deciles, meaning that offsetting the burden on average could still leave many poor households worse off.
[22] These scenarios ignore the effect of the carbon tax on labor income and payroll taxes, which would be especially important in Scenario 4, which assumes 80 percent of the incidence flows through lower wages.

Table 4. Average Labor Income by Income Decile

Decile	Labor Income ($)
Bottom	3,718.24
Second	6,389.67
Third	13,854.64
Fourth	23,954.39
Fifth	36,045.96
Sixth	47,902.31
Seventh	63,015.08
Eighth	80,104.23
Ninth	109,444.41
Top	205,478.17

In reality, the burden on households would depend upon the industry and job category in which they worked, the carbon tax burden on the industry, and the ease with which employers are able to pass on the tax to workers. However, the CEX does not provide information on these worker characteristics, so by necessity we assume that all households bear the burden in the same proportion as their share in total labor income.

Table 5 shows the results of the second simulation. We find that the tax is a little less regressive in this scenario than in the scenario shown in Table 2, which assumed the tax had no effect on wages.[23] The difference arises because higher income households have proportionately more of total national wage income than they do of total consumption, so when some of the burden falls on wage income, they bear a greater share of it. For example, in Table 5, the total burden on the lowest decile is 1.7 percent of initial income; for the prior simulation in which the tax only raises prices, the burden was 2.07 percent of income. The burden on the highest income decile is 0.42 percent of income in Table 5, compared with 0.37 percent in Table 2.

[23] This is in line with results from Metcalf, Hassett and Mathur (2009).

Table 5. Distribution of Carbon Tax Burden by Annual Household Income: Burden Split Across Consumption (80%) and Wages (20%)

Decile	Average Carbon Tax Burden via Consumption ($)	Average Carbon Tax Burden via Wages($)	Average Carbon Tax Burden, Total ($)	Average Total Burden as a Percent of Income	Aggregate Burden ($ Billions)
Bottom	164.56	5.49	170.05	1.712	3.27
Second	199.71	9.44	209.14	1.233	8.03
Third	234.87	20.46	255.33	0.969	9.78
Fourth	257.86	35.37	293.23	0.809	11.26
Fifth	310.90	53.22	364.12	0.764	13.97
Sixth	305.30	70.73	376.03	0.621	14.42
Seventh	396.63	93.05	489.68	0.638	18.83
Eighth	432.73	118.28	551.01	0.569	21.12
Ninth	512.29	161.60	673.89	0.531	25.88
Top	665.78	303.40	969.18	0.422	37.23

Source: Authors' calculations. The table reports the within-decile averages.

Aggregating (as we did in Scenario 1) the burden across the bottom two deciles, our results suggest that the total burden on these low income households is $11.3 billion, so targeting that amount of the carbon tax revenue to them would hold them harmless on average from the carbon tax. The impact on low-income households is marginally lower in this scenario than for the scenario in which all of the carbon tax burden fell on consumption expenditures.

Scenario Three: Accounting for Carbon Tax Effects on EITC Benefits

This scenario extends our prior analysis to investigate how the carbon tax may affect EITC benefits. The primary channel for these effects is via wages. In particular, benefits to households that have income in the phase-in range of the EITC may fall, compounding the burden of the carbon tax. Households in the phase-out region of the EITC could potentially receive greater EITC benefits, in part offsetting the burden of the carbon tax.

Our first step is to estimate the EITC benefits received by households in each income decile. The CEX surveys households about their EITC payments for the previous year, but this income is well-known to be misreported. To better ascribe EITC payments to households, we instead impute EITC payments to households using information on their marital status and the number of children in combination with their labor income. With this approach, we may overestimate benefits since many households that could be claiming the EITC do not, or they receive less through the EITC than they could.

We apply the limits that the IRS imposes on total adjusted gross income and the relevant benefits formulas to impute EITC benefits for each household, and then we aggregate these by households in each income decile. The distribution of benefits across the deciles appears in Table 6. Our imputed EITC benefits, shown in the last three columns, are consistent with the IRS distribution of EITC benefits shown in Table 1, in which no benefits were claimed by individuals earning more than $75,000. Table 6 shows EITC benefits extending up the income ladder in the raw CEX data, but it is unclear why this is so.

Table 6. Reported and Imputed Average Annual EITC Benefits by Income Decile

Decile	CEX Reported EITC, Average Across All Households in Decile ($)	Imputed EITC, Average Across All Households in Decile ($)	Percent of households receiving EITC benefits	Average EITC Benefits Per Recipient ($)
Bottom	503.36	394.53	45.9	859.55
Second	626.63	547.05	25.6	2135.18
Third	903.59	809.75	20.7	3917.02
Fourth	767.94	548.08	20.2	2704.15
Fifth	469.82	277.19	13.7	2019.03
Sixth	279.05	0.00	0.0	0.00
Seventh	230.27	0.00	0.0	0.00
Eighth	81.99	0.00	0.0	0.00
Ninth	58.60	0.00	0.0	0.00
Top	17.15	0.00	0.0	0.00

Next, we reanalyze the scenario, wherein 80 percent of the carbon tax falls on the consumption side and 20 percent on the wage income side, while also taking into account how the EITC benefits change for households as a result of the loss in wage income.

In order to impute the change in the EITC as a result of the loss in wage income, we calculate the new wages after the carbon tax, and apply the EITC payments to the new wages. Finally, we calculate the change in EITC payments as the difference between the EITC payments under the pre-carbon-tax wage and the post-carbon tax wage, both in levels and as a share of pre-tax EITC payments.

Table 7 reports the results. The wage-depressing effect of the carbon tax has virtually no effect on the within-decile average EITC benefits for any of the income deciles when we look across

all households. The effect is more significant when averaging only across EITC beneficiaries, but still small, averaging about $11 more benefits for the fifth decile. The loss in wage income does not result in significant changes in EITC income since the wage loss itself is small and EITC benefits are a small fraction of earned income, as shown in Figure 1. Middle income households lose wages, but because they are in the phase-out region of the EITC, this results in a small increase ($4 to $11) in their EITC benefits. Aggregating across all households, the overall effect on EITC payments would be minor, totaling a loss of $2.76 million for the bottom decile and $0.65 million for the second decile (less than 0.1% of the total burden on each decile).

Table 7. EITC Benefit Changes as Result of Carbon Tax: Burden Split Across Consumption (80%) and Wages (20%)

Decile	Pre-Carbon Tax Average Imputed EITC, All Households ($)	Post-Carbon Tax Average EITC payment, All Households ($)	Change in Average EITC payment due to carbon tax, All Households ($)	Change in Average EITC payment due to tax, EITC recipients only ($)	Aggregate Change in EITC payments resulting from carbon tax ($ millions)
Bottom	394.53	394.31	-0.143	-0.480	-2.76
Second	547.05	547.02	-0.017	-0.099	-0.65
Third	809.75	810.68	0.614	4.507	23.52
Fourth	548.08	549.90	1.187	8.943	45.59
Fifth	277.19	278.71	1.036	11.073	39.74
Sixth	0.00	0.00	0.00	0.00	0.00
Seventh	0.00	0.00	0.00	0.00	0.00
Eighth	0.00	0.00	0.00	0.00	0.00
Ninth	0.00	0.00	0.00	0.00	0.00
Top	0.00	0.00	0.00	0.00	0.00

To see how accounting for the EITC affects the estimated total burden of the carbon tax for households in each decile, we compute the total burden as a share of pre-tax income, including burdens from the consumption side (the higher consumer goods prices), the wage loss and the change in EITC payments. This is shown in the rightmost column in Table 8.

Since the middle decile households get trivially higher EITC payments, it reduced their overall burden marginally, while for lower income households the burden increased marginally. The aggregate burden for all households is $3.27 billion for the first decile and $8.03 billion for the second decile, for a total of $11.3 billion – effectively the same as Scenario Two.

Table 8. Carbon Tax Incidence Before and After Accounting for Changes in EITC Benefits: Burden Split Across Consumption (80%) and Wages (20%)

1	2	3	4	5	6
Decile	Average Carbon Tax Burden (% of income), not accounting for EITC effects (from Table 5)	Average Carbon Tax Burden (% of income) after accounting for EITC effects (All Households)	Average Carbon Tax Burden (% of income) not accounting for EITC effects (EITC Recipient Households Only)	Average Carbon Tax Burden (% of income) after accounting for EITC effects (EITC Recipient Households Only)	Aggregate Carbon Tax Burden after accounting for EITC effects ($ Billions)
Bottom	1.712	1.714	2.696	2.701	3.27
Second	1.233	1.234	2.312	2.313	8.03
Third	0.969	0.967	1.609	1.592	9.75
Fourth	0.809	0.806	1.290	1.266	11.26
Fifth	0.764	0.761	1.337	1.313	13.89
Sixth	0.621	0.621	0.00	0.00	14.42
Seventh	0.638	0.638	0.00	0.00	18.83
Eighth	0.569	0.569	0.00	0.00	21.12
Ninth	0.531	0.531	0.00	0.00	25.88
Top	0.422	0.422	0.00	0.00	37.23

Comparing columns 2 and 3 and columns 4 and 5 in Table 8 shows that on average across households, the burden on the bottom two decile households is essentially the same whether or not one accounts for the effects of the carbon tax on EITC benefits. Either way, for EITC recipients only, the burden is about 2.7 percent of income for the bottom decile and 2.3 percent for the second decile.

Scenario Four: Sensitivity analysis on the split of the burden across consumption and wages

The results above are likely quite sensitive to our assumption about the partitioning of the burden across consumption and wage income. It may be the case that if more of the incidence of the carbon tax falls on wages rather than consumption, the EITC effects might be more important. To test this, we run another simulation (again accounting for the EITC effects) that reverses the partition; it assumes that only 20 percent of the burden is passed on to consumers

in the form of higher prices and 80 percent falls on workers in the form of lower wages. The new results appear in Table 9 below. Column 2 shows the earlier results for comparison.

Table 9. Carbon Tax Incidence Before and After Accounting for EITC Effects: Alternative Burden Split Across Consumption and Wages

1	2	3	4	5	6
Decile	Average Carbon Tax Burden (% of income), 80% consumption/ 20% wage income Accounting for EITC effects, All households (from Table 8, Column 3)	Average Carbon Tax Burden (% of income) 20% consumption/ 80% wage income NOT accounting for EITC effects, All Households	Average Carbon Tax Burden (% of income) 20% consumption/ 80% wage income Accounting for EITC effects, All Households	Aggregate Carbon Tax Burden 20% consumption/ 80% wage income Accounting for EITC effects, All Households ($ Billions)	Aggregate Change in EITC payments resulting from carbon tax, 20% consumption/ 80% wage income ($ millions)
Bottom	1.714	0.636	0.643	1.22	-11.03
Second	1.234	0.510	0.511	3.37	-3.59
Third	0.967	0.533	0.524	5.29	94.06
Fourth	0.806	0.565	0.552	7.73	182.36
Fifth	0.761	0.607	0.598	10.99	158.96
Sixth	0.621	0.592	0.592	13.77	0.00
Seventh	0.638	0.616	0.616	18.12	0.00
Eighth	0.569	0.599	0.599	22.28	0.00
Ninth	0.531	0.608	0.608	29.74	0.00
Top	0.422	0.588	0.588	53.01	0.00

Table 9 shows that the partition of the burden across consumption and wages is far more important to the estimated incidence of the carbon tax than the effects on EITC benefits. Comparing column 4 to column 2, we see that the scenario in which more of the incidence falls on wages is far less regressive than the scenario in which the incidence falls primarily on consumption, even when accounting for the effects on the EITC. In column 4, the aggregate burden on the lowest two deciles of households is $4.59 billion, less than half the estimated burden in the scenario in which most of the incidence flows through consumption. Column 6 shows that even when most of the carbon tax incidence falls on wages, the aggregate change in EITC payments that results from the carbon tax is still very low.

Our results from this section suggest that while in principle EITC payments could be affected by the carbon tax, this is not a significant concern in practice. The two bottom deciles lose less than a dollar on average as a result of the loss in EITC benefits, and the third, fourth and fifth deciles gain very slightly on average through higher EITC payments. While these are small numbers, this shows that once we account for the EITC effect, the carbon tax looks marginally more regressive since the lowest income households lose not only wages but also the EITC. The results also show that far more important to the outcomes of the tax is how the burden ends up falling across consumption and wages. The more the tax reduces wages relative to consumption, the less likely the burden is to fall on the poorest households.[24]

4. EXPANDING THE EITC

Here we suppose that Congress expands the EITC program to childless workers, a policy reform that has been discussed outside the context of climate policy (Marr et al. 2016). If the expansions are funded with carbon tax revenue, then we would want to know the incidence of the combination of the two policies; the carbon tax burdens households, but some of that comes back in a program targeted to low income households. First, we hypothesize a plausible expansion of the EITC that benefits married and single adults with no children, leaving benefits to households with children unchanged. Suppose the EITC expansion:

1) Gives the same benefits to childless married couples that are currently given to married couples with the same income that have one child.
2) Gives single childless adults the same EITC benefits as single parents with the same income that have one child.

We simulate this policy with the methodology described above. Table 10A below shows the distributional impact of these benefits across income deciles. The table shows that this type of expansion would significantly increase the EITC benefits going to lower income households, adding about $9.4 billion and $21.2 billion to the incomes of childless adults in the lowest two income deciles, not counting any shifts as a result of the new incentives to work. Table 10B reports the total change in federal EITC expenditures as a result of this change in benefit schedule. In the aggregate, the EITC expansion would cost an estimated additional $79.6 billion

[24] To the extent that a carbon tax burdens EITC recipients via retail prices, the automatic inflation adjustment of EITC payments can cushion some of the burden. However, inflation adjustment by itself is unlikely to offset all of their carbon tax burden for several reasons. First, indexed transfers, including EITC benefits, form only a small share of most recipients' incomes and thus only a small share of income is indexed. Second, the average consumption patterns of low income households probably differ from the consumption bundle represented in the consumer price index. Finally, research shows that consumption patterns and carbon tax incidence varies widely within income classes, so the extent to which EITC inflation-indexing offsets the burden will vary greatly as well. We leave assessing the significance of the price indexing of transfer payments for carbon tax incidence to future research.

per year (using our data for the year 2014), up from our estimated EITC expenditures from the current program of $62.21 billion, for a total of $141.8 billion for the year.

Table 10A: EITC Expansion to Childless Workers

Decile	Current Program: Average EITC Benefits Across All Households ($)	Expansion to Married Childless Households: Average EITC Benefits Across All Households ($)	Expansion to Single Childless Households: Average EITC Benefits Across All Households ($)	Expansion to Married and Single Childless Households: Aggregate EITC Benefits Across All Households ($ billions)
Bottom	394.53	646.79	889.88	9.37
Second	547.05	912.78	1008.96	21.19
Third	809.75	1504.20	1187.69	27.76
Fourth	548.08	1159.42	697.98	18.97
Fifth	277.19	341.76	283.55	1.70
Sixth	0.00	0.00	0.00	0.00
Seventh	0.00	0.00	0.00	0.00
Eighth	0.00	0.00	0.00	0.00
Ninth	0.00	0.00	0.00	0.00
Top	0.00	0.00	0.00	0.00

Table 10B: Total EITC Expenditures: Current Program and Expansion to Childless Workers ($ billions)

Current Program	Expansion to Married Childless Households	Expansion to Single Childless Households	Expansion to Married and Single Childless Households
62.21	109.86	94.58	142.23

Linking an EITC expansion with a carbon tax

The estimated budget cost of the EITC expansion to married and single childless adults (about $80 billion) is well within the scope of the federal revenue raised by our illustrative $32 per ton tax on CO_2 (about $167 billion). Here we consider the combined incidence of the two policies and explore what net burdens might remain in different demographic categories that can be offset with carbon tax revenue that is not dedicated to the EITC expansion.

Let us decompose the carbon tax incidence results shown above. Tables 11a and 11b show the aggregate and average carbon tax burdens before the EITC expansion respectively, of different categories of households, again assuming a split in the burden of 80% on consumption and 20% on wages. It shows that the aggregate carbon tax burden for EITC participants in the bottom two deciles is lower than for non-EITC participants, whereas their average carbon tax burden is larger (as a share of income). In addition, there are certain families for whom we cannot compute the EITC because of missing information on wages, marital status, number of children etc. These are shown in the last column.

Table 11a. Aggregate Carbon Tax Burdens Before EITC Expansion
Burden Split Across Consumption (80%) and Wages (20%)

1	2	3	4	5	6
Decile	Aggregate Carbon Tax Burden ($ Billions) (From Table 8, column 6)	Aggregate Carbon Tax Burden: Non-EITC participants ($ Billions)	Aggregate Carbon Tax Burden: EITC participants with children ($ Billions)	Aggregate Carbon Tax Burden: EITC participants with no children ($ Billions)	Aggregate Carbon Tax Burden: Those for whom the EITC cannot be imputed ($ Billions)
Bottom	3.27	1.72	0.49	1.02	0.04
Second	8.03	5.34	1.21	1.34	0.14
Third	9.75	7.29	2.18	0.00	0.28
Fourth	11.26	8.43	2.35	0.00	0.48
Fifth	13.89	11.04	2.18	0.00	0.66
Sixth	14.42	13.53	0.00	0.00	0.95
Seventh	18.83	17.74	0.00	0.00	1.02
Eighth	21.12	19.66	0.00	0.00	1.46
Ninth	25.88	24.02	0.00	0.00	1.92
Top	37.23	33.54	0.00	0.00	3.62

Table 11b. Average Carbon Tax Burdens Before EITC Expansion
Burden Split Across Consumption (80%) and Wages (20%)

Decile	Average Carbon Tax Burden, All Households (% of income) (from Table 8, column 3)	Average Carbon Tax Burden: Non-EITC participants (% of income)	Average Carbon Tax Burden: EITC participants with children (% of income)	Average Carbon Tax Burden: EITC participants with no children (% of income)	Average Carbon Tax Burden: Those for whom the EITC cannot be imputed (% of income)
Bottom	1.714	2.517	3.654	2.361	0.058
Second	1.234	1.648	2.216	2.405	0.063
Third	0.967	1.382	1.592	0.00	0.080
Fourth	0.806	1.156	1.266	0.00	0.101
Fifth	0.761	1.024	1.313	0.00	0.112
Sixth	0.621	0.873	0.00	0.00	0.121
Seventh	0.638	0.856	0.00	0.00	0.119
Eighth	0.569	0.781	0.00	0.00	0.123
Ninth	0.531	0.724	0.00	0.00	0.125
Top	0.422	0.548	0.00	0.00	0.134

The table shows that the average carbon tax burden for non-EITC recipients under current law is lower than for EITC recipients with children. For the bottom two deciles, the average burden for recipients with children is substantially larger than that of non-EITC recipients.

In Table 12, we compare the overall incidence on households of the combination of the carbon tax, its EITC effects, and the EITC expansion. The negative numbers in the table show that the EITC expansion to childless adults in aggregate more than compensates the bottom four deciles for the imposition of a carbon tax. For higher income deciles, the burden of the policy combination remains positive, making the package of measures quite progressive overall. However, the benefits of the EITC expansion do not compensate all low income households. While those that benefit from the EITC expansion experience a large net benefit from the policy combination, low income households that do not benefit from the expansion are still left worse off by $5.82 billion for non-EITC recipients and $1.55 billion for EITC recipients with children.

Table 12: Carbon Tax Combined with EITC Expansion
Burden Split Across Consumption (80%) and Wages (20%)

Decile	Aggregate burden of policy combination ($ billions)	Non-EITC Households ($ Billions)	EITC Recipient Households with Children ($ Billions)	EITC Recipient Households without Children ($ Billions)	Those for whom the EITC cannot be imputed ($ Billions)
Bottom	-6.10	1.67	0.34	-8.14	0.04
Second	-13.16	4.15	1.21	-18.66	0.14
Third	-17.98	3.55	1.72	-23.91	0.66
Fourth	-7.68	3.12	2.27	-13.68	0.61
Fifth	12.25	10.48	2.22	-1.11	0.66
Sixth	14.48	13.53	0.00	0.00	0.95
Seventh	18.76	17.74	0.00	0.00	1.02
Eighth	21.12	19.66	0.00	0.00	1.46
Ninth	25.94	24.02	0.00	0.00	1.92
Top	37.16	33.54	0.00	0.00	3.62

Importantly, Table 12 does not account for the disposition of the carbon tax revenue that is not used to expand the EITC. Thus, if policymakers target $18 billion of the remaining revenue to the bottom four deciles, they could on average offset the entire burden of the carbon tax.

As a sensitivity check, we computed the values in Tables 11 and 12 under the assumption of a 20/80 split of carbon tax burden across consumption and wages. As would be expected from Table 9, in this case, the lowest income deciles experience an even stronger net benefit from the carbon tax/EITC expansion policy package. We find that after the EITC expansion, policymakers would need to target only $6.1 billion toward the bottom four deciles to completely offset their burden from the carbon tax.

5. CONCLUSION

This paper investigates the potential linkages between a carbon tax and the EITC. We investigate the potential for a carbon tax to effect EITC benefits via a reduction in wages. Assuming that 20 percent of an illustrative $32 per ton tax on fossil energy CO_2 emissions falls on households via lower wages, we find that the effect on EITC payments is negligible. Some households in the bottom two deciles receive very slightly lower EITC benefits, on average less than a dollar. The EITC offsets the wage loss from the carbon tax burden very slightly for middle income households since they are in the phase-out region of the EITC. A sensitivity analysis shows that far more important to the incidence analysis than EITC benefits is the breakdown of the burden across consumption and wages; the estimated burden of the tax on

the lowest two deciles is twice as high if 80 percent of the burden falls on consumption and 20 percent falls on wages than when the proportions are reversed.

Policymakers could use a carbon tax to fund a long-discussed expansion of EITC benefits for childless workers, thus combining a regressive tax with a progressive benefit. We simulate an expansion of the EITC that gives the same benefits to married couples that are currently given to married couples with the same income that have one child and gives single childless adults the same EITC benefits as single parents with the same income that have one child. We find that the overall estimated budget cost of this expansion would have been about $80 billion in 2014, well below the estimated carbon tax revenue.

When a carbon tax and an EITC expansion are adopted simultaneously, the lower income deciles unambiguously benefit from the package; in aggregate the higher EITC benefit more than offsets the carbon tax burden for the bottom four deciles. However, since our hypothetical EITC expansion only benefits certain childless workers, we find that policymakers would have to target some of the remaining revenue to other low-to-moderate income households if they wish to hold them harmless from the carbon tax. Our results suggest that adopting a carbon tax in the context of an expansion of the EITC can on net significantly benefit low income households while strengthening their incentives to work and providing environmental benefits.

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APPENDIX

The Consumer Expenditure Survey (CEX) data is collected by the U.S. Bureau of Labor Statistics. The CEX provides a continuous and comprehensive flow of data on the buying habits of American consumers. The data are based on two components, the Diary Survey and the Interview Survey. The Diary Survey interviews households for two consecutive weeks and is designed to obtain detailed expenditures data on small and frequently purchased items, such as food items. The Interview sample follows survey households for a maximum of five quarters. The database covers about 95 percent of all expenditures. In addition, the CEX collects information on a variety of socio-demographic variables and income. For this paper, we have used the Interview Survey data collected over the year 2014. As mentioned, the Interview Survey collects household level data where each household is followed for a period of four quarters. It is a rotating sample in which some households drop out of the survey at the end of the four quarters, and are then replaced by a new sample of households. Overall, the 2014 sample has five quarters of data.

For purposes of this study, it is important to note that we made the following changes to the sample. First, for all households, we have only included expenditures that occurred in 2014. The sample contains information for the last quarter of 2013 for the households that were interviewed in January and February of 2014. It also contains information for January and February of 2015 for households interviewed in March of 2015. However, these expenditures are excluded from the analysis since they are not relevant for the year of study. Moreover, we have only included those households for which we have information on all four quarters that is those who were present in the sample throughout 2014. Further, we have only included households with income data. Using these criteria, our sample size is about 7,717 households. We use weights so that the remaining households are representative of the population.

All of these adjustments resulted in aggregate household consumption that is about 56 percent of the actual consumption expenditures in the National Income and Product Accounts. This fits in fairly well with the average ratio of CEX expenditures to NIPA expenditures.[25]

[25] http://www.bls.gov/cex/cecomparison.htm.

Appendix Table 1: Price Increases for Consumer Goods, with a tax of $32 per metric ton of carbon dioxide

	CEX Categories	**2014**
1	Food At Home	1.04%
2	Food at Restaurants	0.66%
3	Food at Work	1.31%
4	Tobacco	0.98%
5	Alcohol	0.89%
6	Clothes	0.54%
7	Clothing Services/Tailors	0.49%
8	Toiletry/Miscellaneous	0.47%
9	Health and Beauty	1.17%
10	Tenant-Occupied Non-Farm Dwellings	0.54%
11	Other Dwelling Rentals	0.54%
12	Furnishings	1.35%
13	Household Supplies	0.86%
14	Electricity	10.89%
15	Natural Gas	10.89%
16	Water	5.34%
17	Home Heating Oil	5.98%
18	Telephone	0.45%
19	Health	0.58%
20	Business Services	0.31%
21	Life Insurance	0.12%
22	Automobile and Parts Purchases	1.26%
23	Other Car services	0.54%
24	Gasoline	6.92%
25	Automobile Insurance	0.12%
26	Mass Transit	1.88%
27	Other Transit	1.99%
28	Air Transportation	1.99%
29	Books/Magazines	0.54%
30	Recreation and Sports Equipment	1.15%
31	Other Recreation Services	0.67%
32	Education	0.90%
33	Charity	0.53%

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