# The Distributional Effects of U.S. Clean Energy Tax Credits

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**Abstract**

Since 2006 U.S. households have received more than $18 billion in federal tax credits for weatherizing their homes, installing solar panels, buying hybrid and electric vehicles, and other "clean energy" investments. We use tax return data to examine the socioeconomic characteristics of program recipients. We find that these tax expenditures have gone predominantly to higher-income Americans. The bottom three income quintiles have received about 10% of all credits, while the top quintile has received about 60%. The most extreme is the program aimed at electric vehicles, where we find that the top income quintile has received about 90% of all credits.

Key Words: Federal Tax Credits, Energy-Efficiency, Solar Panels, Electric Cars

JEL: D30, H23, H24, H50, Q41, Q48

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# 1 Introduction

Most greenhouse gas (GHG) emissions come from burning fossil fuels. Worldwide, humans emit 49 gigatons of $CO_2$-equivalent GHGs each year, with 65% of these emissions coming from electricity generation, transportation, and other fossil-fuel related sources.[1] There is wide agreement among economists that the best policy to reduce GHG emissions and other negative externalities from energy use would be to use a tax or cap-and-trade program. Although there has been some movement in this direction, the vast majority of GHG emissions worldwide remain unpriced.

Instead, the approach that is receiving increased attention, mostly in richer countries, is to *subsidize* lower-GHG alternatives to traditional fossil-fuel based technologies. It can often be easier politically to introduce subsidies than taxes, but the two are not equivalent. Probably the single biggest limitation of technology-based subsidies is that they don't achieve the efficient level of *usage*, but economists have pointed out other limitations as well. For example, Holland et al. (2014) shows that the external benefits from electric cars vary widely (and can even be negative) depending on how electricity is generated.

A growing literature examines the efficiency and overall cost-effectiveness of clean energy technology subsidies, but the distributional effects have received much less attention.[2] In this paper we use tax return data from the Internal Revenue Service to examine the socioeconomic characteristics of taxpayers who receive U.S. federal clean energy tax credits. We focus on four major tax credits aimed at encouraging households to weatherize their homes, install solar panels, buy hybrid and electric vehicles, and make other clean energy investments. Since 2006 tax expenditures for these credits have exceeded $18 billion.

We find that these tax expenditures go predominantly to higher-income Americans. Higher income taxpayers are much more likely to receive these credits and receive larger credit amounts when they claim the credit. Overall, the bottom three income quintiles receive about 10% of all credit dollars, while the top quintile receives about 60%. The most extreme is the program aimed at electric vehicles, where we find that the top income quintile receives about 90% of all credit dollars.

Whether or not this is more regressive than a first-best policy is not clear. Low-income households spend a higher fraction of their income on energy than high-income households, so it is tempting to conclude that first-best taxes on energy are also regressive. However, the distributional impact of a tax also depends on

[1] Edenhofer et al. (2014), p. 42-45.

[2] For recent surveys on subsidies for renewables and energy-efficiency see Borenstein (2012) and Allcott and Greenstone (2012), respectively.

what is done with the revenue that is generated. For example, Bento et al. (2009) show that if revenues are returned lump sum, then a gasoline tax would actually be progressive, with low-income households being made better off on average, even before incorporating externalities.

We also examine data on shipments of energy-efficient appliances, installations of solar photovoltaic systems, and purchases of hybrid and electric vehicles. If these credits were successful in inducing changes in behavior, then we would expect to see increases in adoption during years in which the subsidies are particularly generous. We compare results across the different tax credits and technologies and, where possible, describe relevant related studies from the economic literature.

We see this work as filling an important gap in both the policy and academic literatures. Previous studies have examined the distributional effects of gasoline taxes (Poterba, 1989, 1991; West, 2004; Bento et al., 2009) and carbon taxes (e.g. Hassett et al., 2007; Burtraw et al., 2009; Rausch et al., 2011), but clean energy tax credits have received far less attention. Our work builds on two excellent recent studies (Crandall-Hollick and Sherlock, 2014; Neveu and Sherlock, forthcoming) that review the complete legislative history and report distributional statistics for two out of the four credits in selected years. Our paper extends these analyses to include the entire period since 2006 and reviews all four credits, including those aimed at hybrid and electric vehicles.

## 2 Background

In this section we provide a brief overview of the different clean energy tax credits that have been available to U.S. taxpayers since 2006. For each credit we describe the different technologies that are covered, eligibility requirements, and important changes over time.

### 2.1 Nonbusiness Energy Property Credit

The largest of the tax credits available to U.S. households is the *Nonbusiness Energy Property Credit*, or NEPC. This credit is for homeowners who make energy-efficiency improvements to their homes. Neither renters nor landlords are eligible. The main categories of qualified expenditures are insulation, energy-efficient windows, energy-efficient furnaces, and energy-efficient air conditioning systems.

The NEPC was established by the Energy Policy Act of 2005, and first available in 2006. During 2006 and 2007 the credit was 10%. The credit was not available in

2008, but then reintroduced and expanded in 2009 under the American Recovery and Reinvestment Act. During 2009 and 2010 taxpayers were allowed a 30% tax credit, and the credit limit was temporarily increased to $1,500 up from the prior limit of $500. In 2011, 2012, and 2013 the credit remained in place, but the credit was lowered back to 10% and the maximum credit limit returned to $500. The NEPC expired December 31, 2013. For the complete legislative history see Crandall-Hollick and Sherlock (2014) and Neveu and Sherlock (forthcoming).

Figure 1 plots annual shipments of six different categories of energy-efficient technologies over the period 2005–2013. These data come from the U.S. Department of Energy and represent all U.S. shipments, regardless of whether the buyer ultimately received a tax credit or not. We have selected the six different technologies that were eligible for the NEPC. An important question is the extent to which the NEPC induced real changes in behavior. Most interesting is the surge in the generosity of the credit during 2009 and 2010. If this expansion of the NEPC were leading Americans to invest more in energy-efficiency, we would expect to see this in these data.

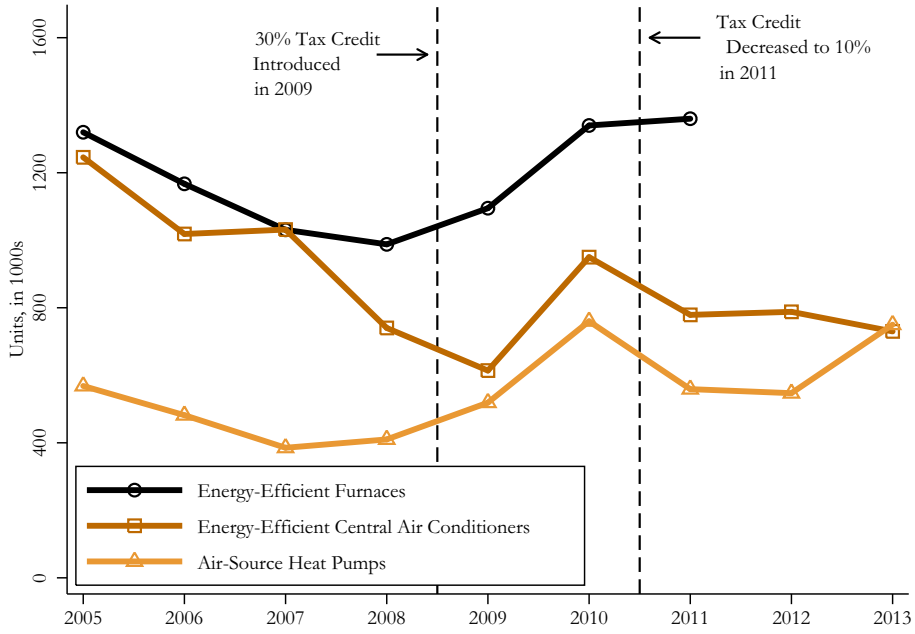
Overall, there is no clear evidence of an increase in shipments in 2009 and 2010. Shipments tend to be relatively high in 2009 and 2010, but is well within the range observed in other years. It is difficult to make strong statements, however, because of several important confounding factors. Most importantly, in 2009 and 2010 the United States was still mired in a prolonged economic downturn and it could well be that, in the absence of the credits, shipments would have been much lower. Without a credible counterfactual it remains an open question exactly how effective these grants have been at stimulating investments in energy-efficient technologies.

## 2.2 Residential Energy Efficient Property Credit

The second largest clean energy tax credit is the *Residential Energy Efficient Property Credit*, or REEPC. This credit is for homeowners who install residential solar panels, solar water heating systems, and fuel cells. Again, neither renters nor landlords are eligible, though there is a parallel program for commercially-owned systems, which we discuss below. Also established by the Energy Policy Act of 2005, the REEPC was first available in 2006 and between 2006 and 2008 there was a 30% credit for all qualified expenditures up to a maximum limit of $2000 for most categories. The credit was expanded in 2008 to include small residential wind turbines and geothermal heat pumps. Starting in 2009 under the American Recovery and Reinvestment Act the maximum credit limit was removed for all qualified investments except fuel cells. This change represented a substantial increase in the generosity of the program because these systems typically cost tens of thousands of dollars. The program has continued

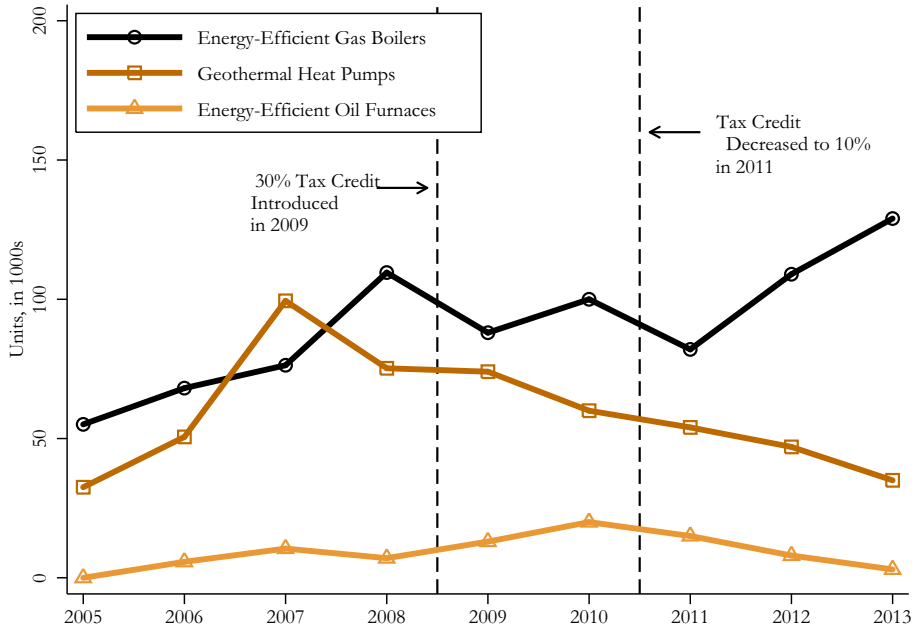
Figure 1: Residential Energy-Efficiency Investments

A: Major Categories



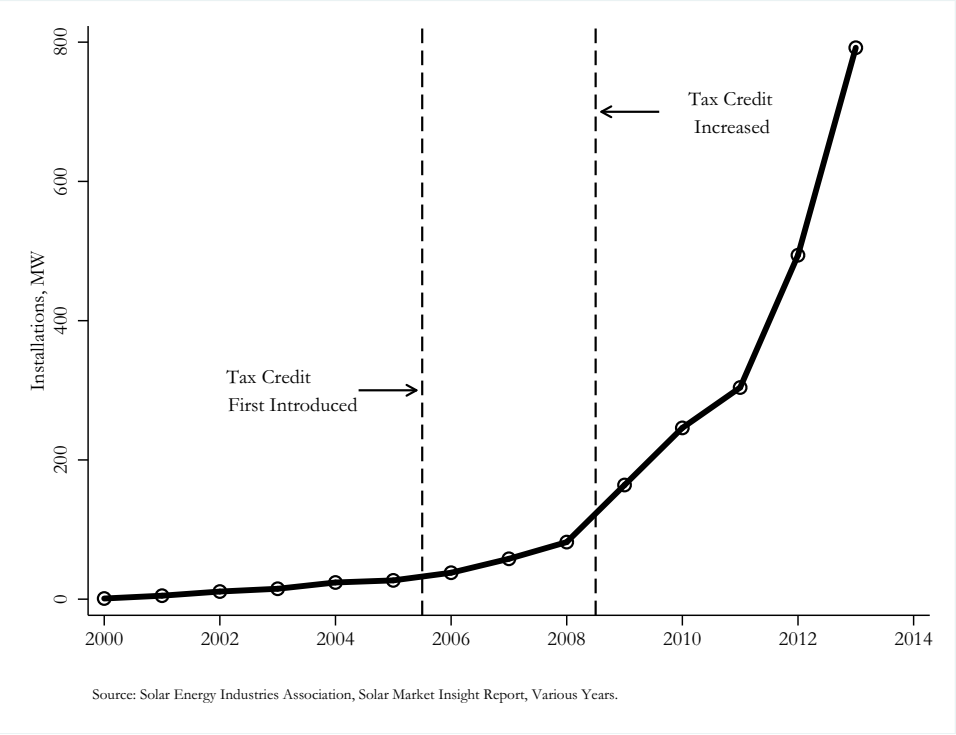

Source: U.S. Department of Energy, Energy Star Unit Shipment and Market Penetration Report, Various Years.

B: Minor Categories




Source: U.S. Department of Energy, Energy Star Unit Shipment and Market Penetration Report, Various Years.

Figure 2: U.S. Residential Installations of Solar Panels

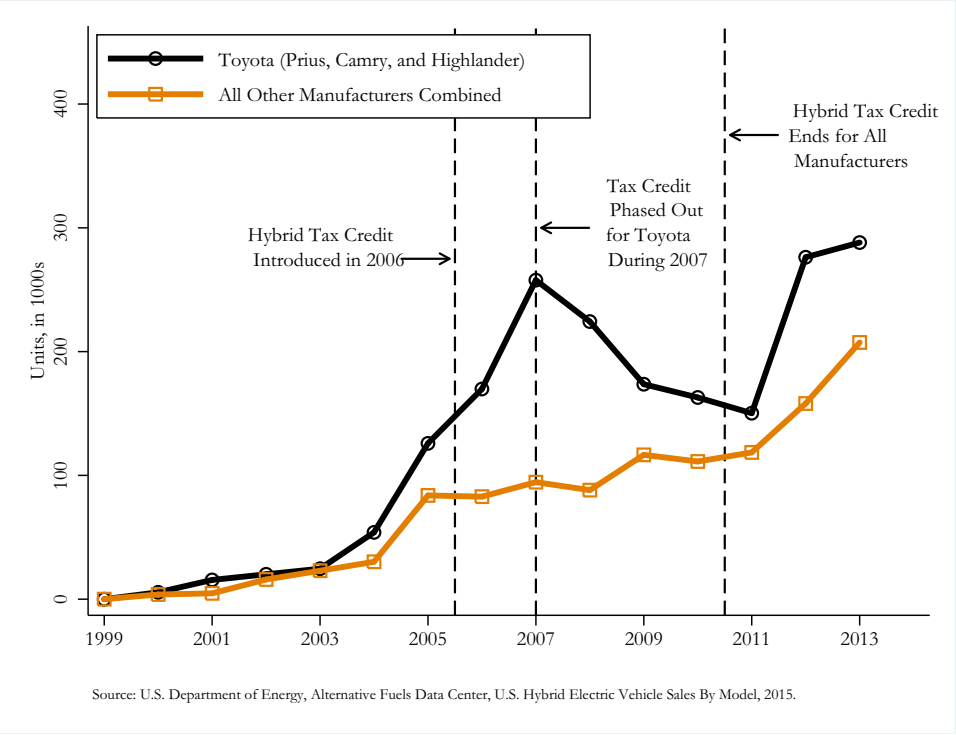



unchanged since 2009 and is scheduled to end on December 31, 2016.

Figure 2 plots annual installations of residential solar photovoltaic systems, measured in megawatts of capacity. These data come from a solar industry association and include all installations in the United States. Between 2000 and 2013 there has been a rapid and continual increase in installations. This has been widely attributed to several factors including technological change and sharp decreases in solar panel prices. The REEPC also likely plays an important role particularly beginning in 2009 when the generosity of the program was substantially increased, though it is difficult to make causal statements based on these before-and-after comparisons. Evidence from solar incentives in California indicates that households are indeed responsiveness to subsidies (Hughes and Podolefsky, forthcoming), but it is not straightforward to generalize these results to the rest of the United States.

The REEPC and NEPC are both based on similar credits that were available during the late 1970s and early 1980s (Dubin and Henson, 1988; Hassett and Metcalf, 1995). These credits expired at the end of 1985 and between 1986 and 2005 there were no such federal tax credits. Dubin and Henson (1988) finds that credits claimed in 1979 were higher where winters were more severe and where energy prices were high. In addition, both Dubin and Henson (1988) and Hassett and Metcalf (1995) test whether take-up of the federal credits is higher in states with state-level incentive programs

Figure 3: U.S. Hybrid Vehicle Sales




for energy efficiency. Dubin and Henson (1988) finds a positive but not statistically significant effect while Hassett and Metcalf (1995), using panel data, finds a positive and statistically significant effect.

## 2.3 Alternative Motor Vehicle Credit

The *Alternative Motor Vehicle Credit* (AMVC) is for purchases of qualified hybrids, as well as natural gas, hydrogen, fuel cell, and other alternative vehicles. The credit was first available in 2006, with credit amounts varying from $400 to $4000 depending on the vehicle model. The AMVC replaced a less generous $2000 clean fuel vehicle *deduction* that was in place in 2003, 2004, and 2005. The AMVC includes an unusual "phase-out" rule that limits the total amount of the credit that can go to any particular vehicle manufacturer. In particular, the AMVC phases out during the calendar year after which the manufacturer sells 60,000 qualifying vehicles. Toyota and Lexus were phased out first in 2007, followed by Honda in 2008 and Ford and Mercury in 2009. The AMVC was ended for hybrids on December 31, 2010 and the AMVC is currently available only for fuel cell vehicles.

Figure 3 plots U.S. hybrid sales between 1999 and 2013. We break out Toyota from all other manufacturers because it has been so dominant in this market and

because the Toyota tax credit was phased out before the tax credit for most other manufacturers. The AMVC was available for Toyota vehicle only in 2006 and for part of 2007. Notably, Toyota hybrid sales appear to have been particularly strong in those years. This is consistent with Sallee (2011) who finds sales spikes for the Toyota Prius just before the tax credit was phased out.

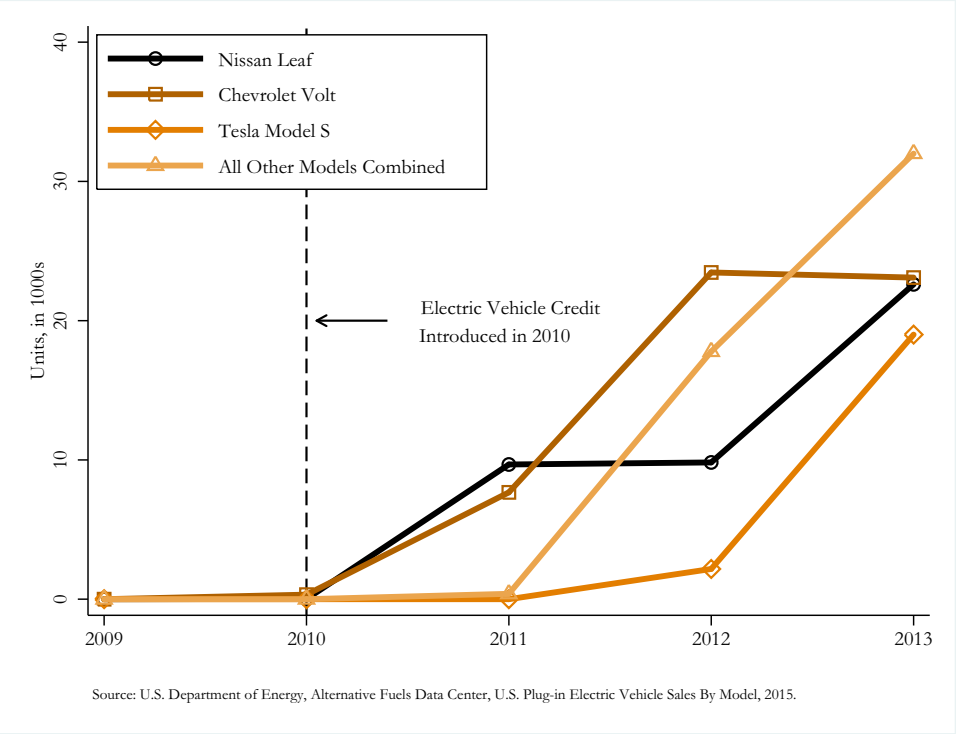
There does not seem to be much impact, in contrast, when the AMVC was ended for all hybrids at the end of 2010. Hybrid sales increased in 2012 and 2013 and have done so without benefit of the AMVC. That said, it is again difficult to make causal statements on the basis of this before-and-after comparison. The most convincing evidence to date on the effectiveness of hybrid vehicle subsidies comes not from federal tax credits, but from state-level subsidies. In particular, Gallagher and Muehlegger (2011) uses panel data to measure the effect of state-level hybrid subsidies on the adoption of hybrids, finding economically and statistically significant impacts.

### 2.4 Qualified Plug-in Electric Drive Motor Vehicle Credit

Finally, the *Qualified Plug-in Electric Drive Motor Vehicle Credit* (PEDVC) is a credit for electric vehicles and plug-in hybrid vehicles purchased beginning in 2009. This credit was implemented later than the other three tax credits and, so far, has been the smallest of the four in terms of total expenditures. The size of the credit ranges from $2,500 to $7,500 depending on the battery capacity of the vehicle. For example, the Toyota Prius plug-in hybrid qualifies for a $2,500 credit whereas the Chevrolet Volt qualifies for a $7,500 credit. Similar to the AMVC, the PEDVC is phased out for a manufacturer's vehicles during the calendar year after which that manufacturer sells 200,000 qualifying vehicles, but no manufacturer has yet reached this threshold. Nissan has sold more qualifying vehicles than any other manufacturer but is still only about halfway there as of December 2014. The PEDVC remains in place and is not scheduled to expire.

We exclude from the analysis two closely related, but much smaller vehicle-related credits. First, the *Qualified Plug-in Electric and Electric Vehicle Credit* (PEVC) which from 2009-2012 provided credits similar to the PEDVC for certain low-speed "neighborhood electric vehicles" or, somewhat surprisingly, golf carts. The PEVC ended December 31, 2012. Second, the *Alternative Fuel Vehicle Refueling Property Credit* (AFVRPC) provides a 30% credit up to $1000 for equipment used for refueling natural gas, hydrogen, or other alternative fuel vehicles. Charging stations for electric vehicles are also eligible. The AFVRPC has been around in different forms since 1992 and is not scheduled to expire. Both of these credits are modest compared to the other credits we consider. For example, in 2012, total credits for the PEVC and

Figure 4: U.S. Sales of Electric and Plug-In Hybrid Vehicles




Source: U.S. Department of Energy, Alternative Fuels Data Center, U.S. Plug-in Electric Vehicle Sales By Model, 2015.

AFVRPC were $5 million and $8 million, respectively, compared to $139 million for the PEDVC.

Figure 4 plots U.S. electric and plug-in hybrid vehicle sales between 2009 and 2013. We have broken out separately sales for the Nissan Leaf, the Chevrolet Volt, and the Tesla Models S, the three best-selling vehicles in this category. These data come from the U.S. Department of Energy which tracks monthly sales of electric and plug-in hybrid vehicles by model since December 2010.[3] The Nissan Leaf and Chevrolet Volt were both introduced in December 2010, the Toyota Prius Plug-in Hybrid was introduced in January 2012, and the Tesla Model S was introduced in June 2012.

Electric and plug-in hybrid vehicle sales have grown rapidly since 2010. Much like with the pattern for residential solar photovoltaic systems, the tax credits have been in place for essentially the entire period of increased electric vehicle sales so it is tempting to attribute a large causal impact. Again, however, this is simply not possible to make definitive causal statements on the basis of before-and-after comparisons. This period also coincides with a period of sustained oil prices above $75 per

[3]In constructing the figure, sales during 2009 and the first 11 months of 2010 were assumed to be zero. During these months the only electric vehicle which was for sale in the United States was the Tesla Roadster, which sold a total of 1,650 total units between March 2008 and April 2011 when production ended. See, e.g., CNN Money, "Tesla Roadster Reaches the End of the Line," Peter Valdes-Dapena, June 22, 2011.

Table 1: Annual Expenditures on U.S. Clean Energy Tax Credits, in Millions

| Year | Nonbusiness Energy Property Credit (NEPC) | Solar Panels and Other Residential Renewables (REEPC) | Hybrids and Other Alternative Fuel Vehicles (AMVC) | Electric and Plug-In Hybrid Vehicles (PEDVC) |
|---|---|---|---|---|
| 2005 | $0 | $0 | $0 | $0 |
| 2006 | $957 | $43 | $50 | $0 |
| 2007 | $938 | $69 | $185 | $0 |
| 2008 | $0 | $217 | $49 | $0 |
| 2009 | $5177 | $645 | $137 | $129 |
| 2010 | $5420 | $754 | $93 | $1 |
| 2011 | $755 | $921 | $14 | $76 |
| 2012 | $449 | $818 | $20 | $139 |
| Total | $13696 | $3467 | $549 | $346 |

Note: This table was constructed by the authors using U.S. Department of the Treasury, Internal Revenue Service, "Statistics of Income, Individual Tax Returns," 2005–2012 and U.S. Department of the Treasury, Internal Revenue Service, "Individual Income Tax Returns Line Item Estimates," 2005–2012. See Appendix A for details. Tax credits across all four categories totaled $18.1 billion between 2005 and 2012.

barrel and a recovering economy since 2012. Teasing out the relative impact of the federal credits compared to these other factors is not possible in this setting.

## 2.5 Summary of Total Tax Expenditures

Table 1 reports annual expenditures for the four major clean energy tax programs. Between 2006 and 2012, total expenditures were $18.1 billion. By far the largest program is the NEPC, with $13.7 billion in total tax expenditures over this period. The REEPC is also substantial, with $3.5 billion in total tax expenditures, while the two vehicle credits are considerably smaller, adding up together to about $900 million.

There are large changes across years. Perhaps most strikingly, there is a dramatic surge in expenditures for the NEPC in 2009 and 2010 after the credit was reinstated with a 30% tax credit with temporarily higher $1,500 credit limit. Tax expenditures exceed $5 billion annually in each year. Recall that Figure 1 showed little clear evidence of an increase in shipments of energy-efficient products during 2009 and 2010, so it would appear that at least some of those credit dollars went to taxpayers who would have purchased those products anyway.

Tax expenditures for the REEPC approximately triple in 2009 when the credit limit was removed. Expenditures on the REEPC then continue at approximately the same level between 2009 and 2012. This is perhaps surprising given the enormous increase in residential solar photovoltaic system installations in Figure 2. The lack of a corresponding increase in tax expenditures likely reflects, in part, a well-documented

move in the solar industry toward third-party leasing.[4]

The size of the AMVC and PEDVC varies substantially across years too. For example, tax expenditures for the AMVC decreased in 2008 after Toyota vehicles became ineligible and then increases again in 2009 as more eligible hybrid models become available. Hybrid vehicles are no longer eligible for the AMVC beginning in after 2010 and the program becomes much smaller. Finally, the PEDVC varies across years.[5] IRS data are not yet available for 2013 and 2014 but electric vehicle sales have continued to increase during this period so expenditures on the PEDVC have presumably increased as well.

The tax expenditure totals for the AMVC suggest that a relatively small fraction of hybrid buyers received the credit, at least during the first year of the program. Based on sales data from *Automotive News* and assuming an 85% take-up rate, Sallee (2011) estimated that total credits in 2006 would have been $426 million. In the IRS Statistics of Income data, however, total expenditures on the AMVC in 2006 were only $50 million. The discrepancy suggests that only approximately 1 in 8 hybrid buyers actually received the credit. This is a bit of a puzzle because while undoubtedly some buyers had zero net tax liability in 2006 and thus were unable to claim the credit, it seems highly unlikely that this could explain such a large discrepancy. Another possibility is that buyers were unable to claim the credit because they were subject to the Alternative Minimum Tax. Or, it may also have been that some buyers simply didn't know about the credit or forgot to claim it.

Appendix Table B1 provides additional details on specific categories of spending. The NEPC goes mostly to energy-efficient windows (29%), furnaces (18%), heat pumps and air conditioning (17%) and insulation (15%), with average credit amounts across these categories ranging from $200 to $700. The REEPC goes to solar panels (54%), geothermal heat pumps (35%), and solar water heating systems (10%), with much larger average credits, usually more than $1000, and above $5000 for households who install solar panels.

[4]Between 2006 and 2010 a majority of residential solar PV systems were purchased and owned by homeowners themselves. By 2011, however, third-party leasing had become much more common. When a system is leased the homeowner is no longer able to use the REEPC, but there is a similar 30% credit available for third-party companies and, in addition, third-party companies are able to take advantage of generous rules for accelerated depreciation. See Borenstein (2015) for details.

[5]The $129 million in 2009 is puzzling because no mass-market electric or plug-in hybrid vehicles were available in that year. Treasury has investigated this and concluded that thousands of taxpayers (including several IRS employees) erroneously claimed the PEDVC, as well as the AMVC, in 2009. In later tax years the IRS made changes to drastically reduce the number of credits claimed erroneously. See U.S. Treasury Inspector General for Tax Administration, "Individuals Received Millions of Dollars in Erroneous Plug-in Electric and Alternative Motor Vehicle Credits," January 2011, 2011-41-011.

# 3 Distributional Analysis

Having provided an overview of these clean energy tax credits we now turn to our main research question. What are the socioeconomic characteristics of the tax filers who receive these credits? In this section we use detailed data from the IRS *Statistics of Income* program to calculate the share of the credit going to different income groups. We compare average credit amounts by income category, construct Lorenz curves, and calculate Gini coefficients. Finally, the last subsection contrasts the distributional characteristics of these credits with other major U.S. tax credits.

## 3.1 Average Credit Amount by AGI

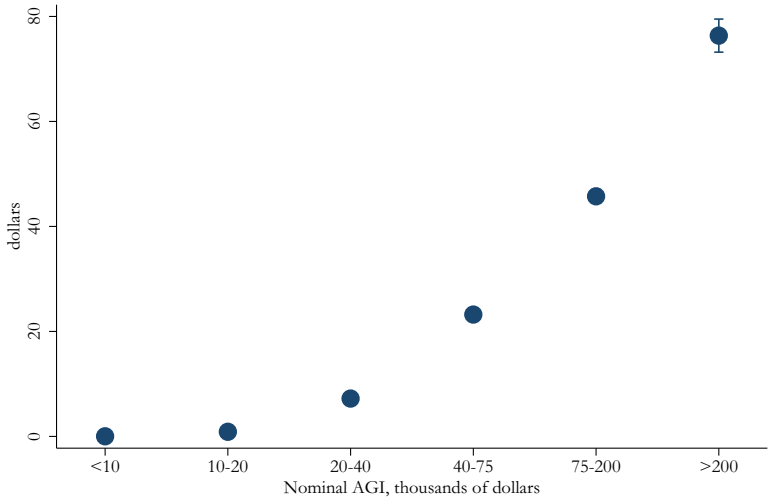
Figure 5 plots the average credit amount per return by adjusted gross income (AGI) category. These figures were constructed by the authors using data from the IRS *Statistics of Income* program and Appendix A provides a complete description of the data we used and how we made these calculations. Reported on the y-axis in these figures is the average credit per return. That is, we take an average over all tax returns, including both filers who did and did not claim these credits. Thus, for example, the far right observation on the first panel means that, among all filers with more than $200,000 in AGI, the average amount claimed in residential energy credits was about $80. We pool data from across all years in which data is available as described in the panel headings.

In this figure and in most of the analyses that follow we focus on three categories of credits: (1) *Residential Energy Credits*, (afterward, RECs) (2) *Alternative Motor Vehicle Credit* (AMVC), and (3) *Qualified Plug-in Electric Drive Motor Vehicle Credit* (PEDVC). Category (1) is the combination of the NEPC and the REEPC whereas categories (2) and (3) are exactly the same as in the previous section. The NEPC and REEPC are are quite different, as we explained in the previous section, but neither the IRS' annual reports nor the IRS public-use microdata report separate statistics for the two programs.

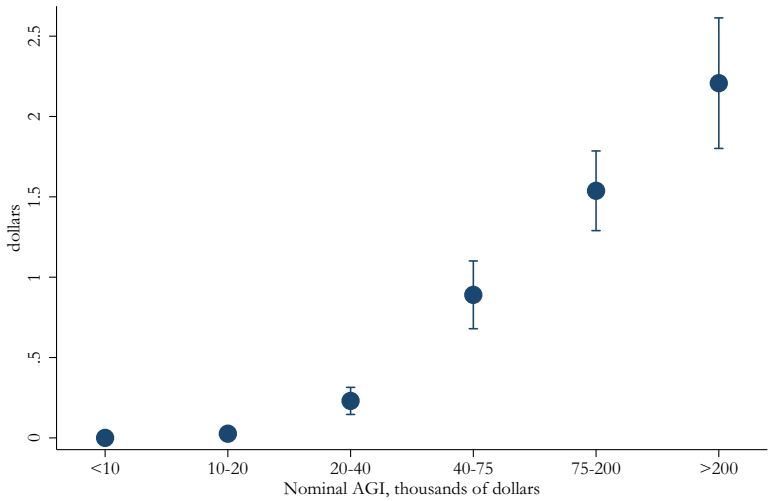
We have divided AGI into six categories. The first five are approximately quintiles, and then the last category ($200,000+) includes about 3% of returns. The figures also include 95th percentile confidence intervals. The IRS' annual reports from which we calculated these average credit amounts is based on a large representative sample of tax returns. Fortunately, the IRS also reports standard errors for all estimates which we have used to construct 95th confidence intervals. See Appendix A for details. For the most part the underlying sample is large enough that the sampling variation is small.

Figure 5: Average Credit Per Return, by Adjusted Gross Income

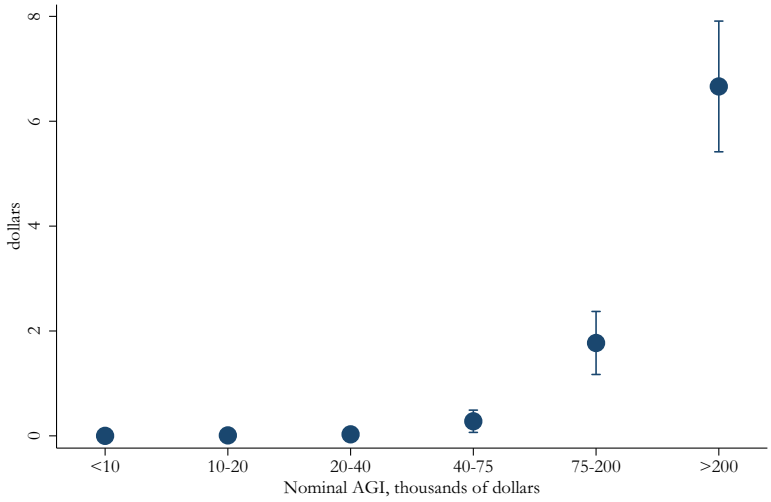
A: Residential Energy Credits, 2006-2012




B: Alternative Motor Vehicle Credit, 2007-2012




C: Qualified Plug-in Electric Drive Motor Vehicle Credit, 2009-2012



About 60% of tax filers have less than $40,000 in AGI and these filers receive very little of any of the three categories of clean energy credits. In the discussion and analysis that follows we consider several potential explanations for this near zero take-up among lower income tax filers. Average credit amounts increase steadily with AGI. With the RECs, the average credit amount in the top income category ($200,000+) is almost twice as high as the average credit amount in any other category. The AMVC is more evenly divided across categories, while still clearly increasing in AGI. Finally, the PEDVC is by far the most concentrated. On average, the top AGI category ($200,000+) receives more than three times the average amount received by filers in any other income category.

These are tax credits, not deductions, so this correlation between credit amounts and income is not mechanically introduced by increasing marginal tax rates. Deductions are subtracted from income before calculating the amount of tax which must be paid. Consequently, deductions are more valuable for tax filers facing a higher marginal tax rate. In contrast, credits are applied dollar-for-dollar against whatever tax is due, regardless of the taxpayer's marginal tax rate.

What is important, however, is that all four clean energy tax credits are non-refundable, which means that they can only be used by taxpayers with positive tax liability. In 2012, for example, the IRS received 144.9 million tax returns, of which 93.1 million had positive tax liability. The other 51.8 million tax returns (35.7%) had non-positive tax liability. This tends, overwhelmingly, to be filers with less than $30,000 in AGI, and these filers cannot receive any of these tax credits. Another potential explanation for the correlation with income is that the residential energy credits, in addition, require that a filer be a homeowner and many filers in these lower AGI categories are not homeowners.

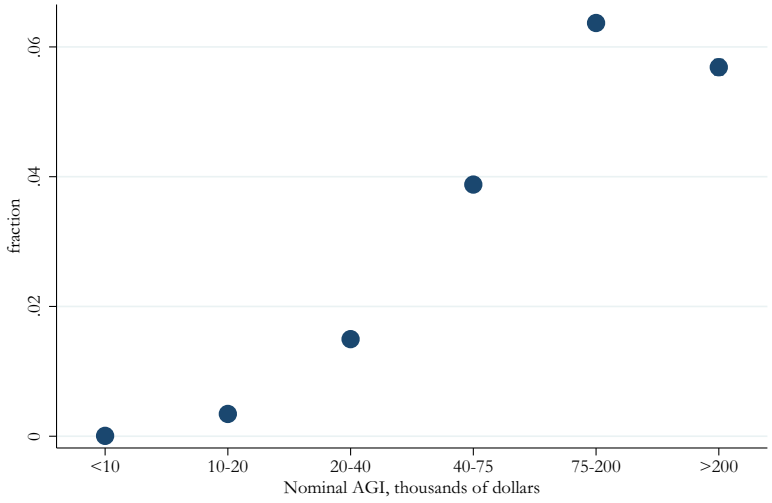
We also have examined how the relationship between average credit per return and income has changed over time. Appendix Figures B1, B2, and B3 plot year-by-year versions of our Figure 5. Overall, the pattern is extremely similar across years. However, there is one important finding in the year-to-year comparisons. The RECs are considerably more regressive in 2011 and 2012 than in other years, with filers with $200,000+ in AGI receiving a considerably higher fraction of total credit dollars. As we showed in Table 1, in these two years annual expenditures on the REEPC have grown to eclipse annual expenditures on the NEPC. Thus, it appears that the two programs have different distributional characteristics, with the former tending to be considerably more regressive. This is consistent with photovoltaic systems and other technologies under the REEPC being more concentrated in the higher income categories.

## 3.2 Extensive Versus Intensive Margin

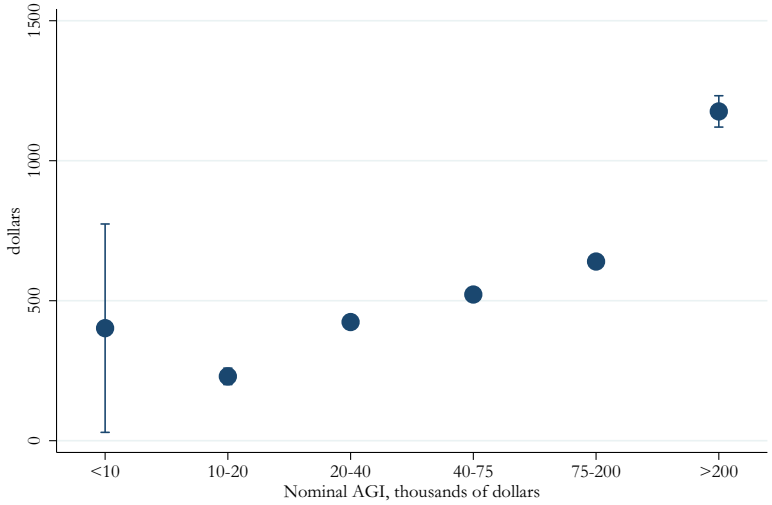
The correlation between average credit per return and income reflects *both* an increase in the share of filers claiming the credits and an increase in the average credit amount claimed. Figure 6 compares the extensive versus intensive margin for the RECs. The top panel shows that the share of filers claiming the credit increases steadily from less than 1% for filers with income below $20,000 to above 6% for filers with income $75,000–$200,000. Above $200,000 the share claiming the credit falls slightly, perhaps due to some filers being subject to the Alternative Minimum Tax, and thus ineligible.

Figure 6: Residential Energy Credits, Extensive Versus Intensive Margin

A: Share Claiming Credit 2006-2012, by Adjusted Gross Income




B: Average Credit Amount Claimed 2006-2012, by Adjusted Gross Income



The bottom panel in Figure 6 plots the average credit amount claimed among filers who claimed the credit. Very few filers with income below $10,000 receive the credit, so the 95th percentile confidence interval is wide. Across the other income categories, there is a clear positive relationship between AGI and the average credit claimed. This is most clear in the highest income category. Filers with $200,000+ in AGI claim on average $1200, compared to $600 for filers with income $75,000–$200,000.

Analogous results for the AMVC and PEDVC are presented in Appendix Figures B4 and B5. The share of filers claiming the credit increases steadily with income for both vehicle credits, with the top income categories several times more likely to claim the credit than other income categories. There appears also to be a positive relationship between income and the average credit amount claimed, but this is less precisely estimated.

### 3.3 Lorenz Curves and Gini Coefficients

We now construct Lorenz curves to examine the progressivity of the credits. Income itself is highly concentrated, so the Lorenz curves allow us to ask how the distributional pattern of credit receipts compares to the distributional pattern of income. In particular, are credit receipts approximately proportional to income, or more or less concentrated?

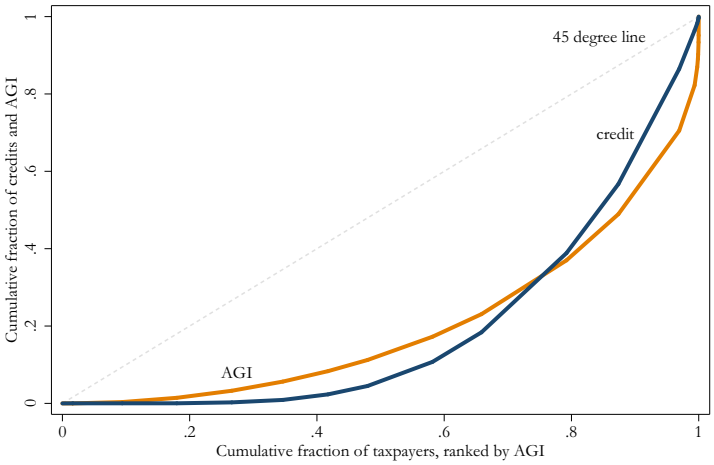
Figure 7 plots Lorenz curves for the three different categories of credits. We constructed these figures using these same data from the IRS *Statistics of Income* program, except that we now use all 19 income categories rather than just the six categories used in the previous subsection. Along the horizontal axis is the cumulative fraction of taxpayers, ranked by AGI. The income curve plots the the cumulative fraction of total AGI, while the credits curve plots the cumulative fraction of total credits. If the credits were equally distributed across filers with different income levels then the curve would exactly follow the 45 degree line with, for example, the richest 50% of filers receiving 50% of the credits. The farther below the 45 degree line, the more regressive the credits.

The RECs and AMVC have very similar distributional patterns. In both cases, the credits are *more* concentrated than income for low income levels, but then *less* concentrated than income for high income levels. Take the 50th percentile, for example. The bottom 50% of filers represent about 15% of all income, but less than 10% all credits. The two curves cross at about the 75th percentile, so the bottom 75% of filers account for about 30% of all credits and about 30% of all income.

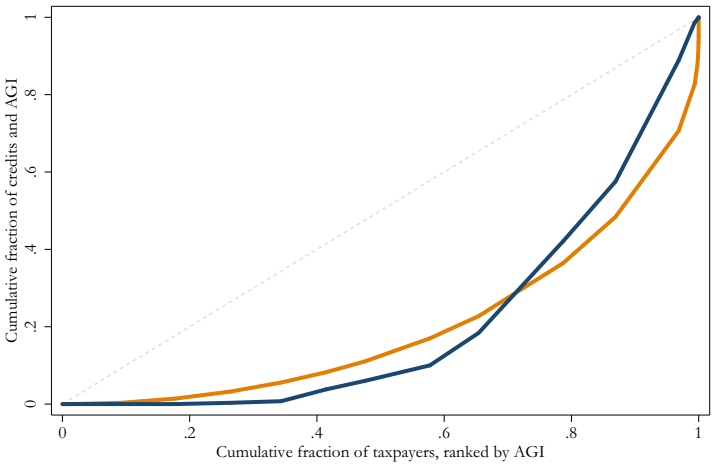
This pattern reflects several features of these credits and the broader tax code. Prob-

Figure 7: Lorenz Curves

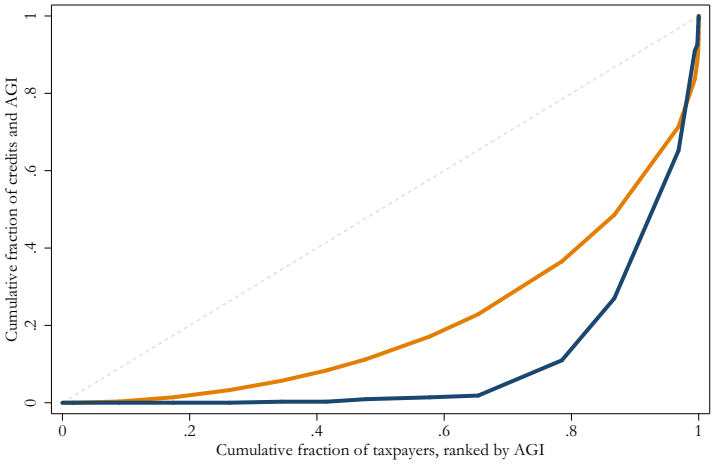
A: Residential Energy Credits, 2006-2012




B: Alternative Motor Vehicle Credit, 2007-2012




C: Qualified Plug-in Electric Drive Motor Vehicle Credit, 2009-2012



ably most importantly, these credits are non-refundable so they cannot be claimed by filers with zero net tax liability. This helps explain low take-up of the credits at very low income levels. On the high end, the maximum credit limits begin to become important. The NEPC, for example, has since 2011 had a $500 maximum credit limit. Thus, at high income levels the NEPC necessarily becomes a smaller fraction of total income even for filers claiming the maximum credit.

The PEDVC is much more concentrated than the other categories of credits. The bottom 80% of filers receive a little more than 10% of all credits, and the bottom 90% of filers receive only about 40% of all credits. Even after the credit, electric and plug-in electric drive vehicles are expensive compared to equivalently-sized vehicles that use gasoline. So it may simply be that these are products which, at least for the moment, are only affordable for relatively rich households. Another explanation that has been suggested is that in "green" communities (which tend to be high income), driving an energy-efficient vehicle could be perceived as a symbol of status. Kahn (2007) makes this argument about hybrids, but it could be made about electric vehicles as well.

### 3.4 Comparisons to Other Tax Credits

Table 2 compares the distributional pattern of the clean energy tax credits to the five largest U.S. tax credits in terms of total tax expenditure. For each credit we report the percentage of credit dollars received by income category, as well as the Gini coefficient, calculated as usual as the ratio of the area between the Lorenz curve and the 45 degree line over the total area under the 45 degree line. A Gini coefficient of zero indicates perfect equality, whereas one indicates perfect inequality with all credit dollars concentrated in the single highest-income filer. Negative Gini coefficients are possible when the Lorenz curve lies above the 45 degree line, e.g. more than 50% of credits are received by the bottom 50% of filers in terms of AGI.

The clean energy tax credits are considerably more regressive than most other tax credits. The Earned Income Tax Credit is strongly progressive by design and reaches a maximum for filers with AGI between about $10,000 and $20,000, depending on filing status and number of children, and then phases out sharply for most filers between about $20,000 and $40,000. The Making Work Pay Credit, Child Tax Credit, and First-time Homebuyer Credit are also considerably more progressive than the clean energy tax credits, with Gini coefficients between .163 and .230. The Foreign Tax Credit, for taxpayers who paid taxes to a foreign country, has a very different pattern with 88% of all credits going to the filers with $200,000+ in AGI. This includes qualified dividends, capital gains, interest and other forms of investment earnings,

Table 2: Distributional Effects of Selected Tax Credits

| | Percent of Credit Received by Income Category (in thousands) | | | | | | Gini Coefficient |
|---|---|---|---|---|---|---|---|
| | $0–$10 | $10–$20 | $20–$40 | $40–$75 | $75–$200 | $200+ | |
| **Panel A. Clean Energy Tax Credits** | | | | | | | |
| Residential Energy Credits | 0% | 1% | 10% | 28% | 48% | 14% | 0.606 |
| Alternative Motor Vehicle Credit | 0% | 1% | 9% | 32% | 47% | 11% | 0.584 |
| Plug-in Electric Drive Vehicle Credit | 0% | 0% | 1% | 10% | 54% | 35% | 0.801 |
| **Panel B. Other Major Tax Credits** | | | | | | | |
| Earned Income Tax Credit | 18% | 49% | 32% | 1% | 0% | 0% | –0.415 |
| Making Work Pay Credit | 7% | 14% | 25% | 28% | 26% | 0% | 0.163 |
| Child Tax Credit | 2% | 13% | 31% | 31% | 23% | 0% | 0.185 |
| First-time Home Buyer Credit | 7% | 6% | 23% | 40% | 24% | 1% | 0.222 |
| Foreign Tax Credit | 0% | 0% | 1% | 2% | 9% | 88% | 0.954 |

Note: This table was constructed by the authors using U.S. Department of the Treasury, Internal Revenue Service, "Statistics of Income, Individual Tax Returns," 2005–2012. The first five income categories are approximate quintiles (18%, 17%, 24%, 21%, 18%), and 3% of tax returns fall in the last category. Residential energy credits includes both the NEPC and the REEPC. See Appendix A for details.

mostly relevant to relatively wealthy taxpayers with investments abroad.

About 60% of the RECs and AMVC are received by filers with AGI in excess of $75,000, and about 90% of the PEDVC is received by filers with AGI in excess of $75,000. The Gini coefficient for the clean energy tax credits range from .591 to .808, much higher than four out of the five other major tax credits. Whereas none of the clean energy tax credits are refundable, several of the other major tax credits are refundable. In particular, the Earned Income Tax Credit, Making Work Pay Credit, and the First-Time Home Buyer Credit are all refundable, while the Child Tax Credit and Foreign Tax Credit are not.

Interestingly, the distributional pattern for the RECs is similar to the pattern observed 25+ years ago with the energy-efficiency tax credits that came out of the Federal Energy Tax Act of 1978. Dubin and Henson (1988) finds that these earlier tax credits were somewhat regressive, with a Gini coefficient of 0.572 which compares closely to the 0.606 reported above. Using the same data, they find that the Gini coefficient for income is 0.423. We find a considerably higher Gini coefficient for income, ranging from .586 to .592 depending on exactly which years we use. This increase in the concentration of income has been widely documented. See, e.g., Piketty and Saez (2014) which documents a steady increase since 1970 in the share of total U.S. income accruing to the top decile.

# 4 Conclusion

There is growing enthusiasm among policymakers for programs that subsidize clean energy technologies. In addition to the federal tax credits examined here, most states now have renewable portfolio standards which subsidize electricity generation from renewables, state-level subsidies for hybrid and electric cars are widely available, and U.S. electric and natural gas utilities spend billions annually on energy-efficiency programs.[6] These subsidies for clean energy technologies would increase further under the U.S. Environmental Protection Agency's Clean Power Plan.

To date most of the economic analysis of these programs has examined the scope for emissions reductions in these sectors and on the overall costs and benefits. Whether credits like these are welfare improving hinges, ultimately, on the magnitude of the external benefits and on the marginal cost of public funds. Our analysis does not and cannot answer these questions. We focused, instead, on understanding the distributional effects. We examined U.S. federal tax credits which, since 2006, have provided more than $18 billion in subsidies for households who make clean energy investments. Using rich data from tax returns we show that these tax expenditures have gone predominantly to higher-income Americans.

It makes sense that most households in a position to purchase a new $25,000+ car or to spend thousands installing solar panels are going to tend to be relatively affluent. Indeed, several of these credits are explicitly restricted only to homeowners, which already tends to skew these credits toward higher-income households. What our work highlights, however, is the degree of concentration. The distribution is particularly skewed in the case for electric vehicle incentives, where we find that tax filers who earn $75,000+ annually receive about 90% of all credits.

This distributional pattern is important because many recipients are inframarginal. We examined shipments of energy-efficient appliances, installations of solar photovoltaic systems, and purchases of hybrid and electric vehicles. It is hard to make causal statements based on before-and-after comparisons but the evidence on energy-efficient appliances, in particular, suggests that a substantial fraction of these credit recipients would have adopted these technologies even without the subsidy. Moreover, several recent studies of similar programs find that large numbers of subsidy recipients are inframarginal (Mian and Sufi, 2012; Boomhower and Davis, 2014; Hughes and Podolefsky, forthcoming). For inframarginal participants there are no efficiency

[6] For energy-efficiency spending see U.S. Energy Information Administration, Form EIA-861, "Annual Electric Power Industry Report," Table 10.5, 'Demand-Side Management Program Direct and Indirect Costs' accessed online February 2015 at `http://www.eia.gov/electricity/annual/html/epa_10_05.html`. Many utility-sponsored programs are similar to tax credits in that they provide subsidies for consumers who purchase energy-efficient products and technologies.

gains, so the primary effect is distributional.

Probably more importantly, this distributional pattern is troubling because of what it means for cost-effectiveness. Studies have shown that smaller, less insulated homes tend to offer the highest rate-of-return for energy-efficiency investments (Dubin and Henson, 1988; Borenstein and Davis, 2012; Fowlie et al., 2015), but many lower-income taxpayers are ineligible because these are non-refundable tax credits. We have not been able to come up with any coherent economic argument for making these credits non-refundable. From an efficiency perspective, there is nothing fundamentally different between filers with positive and negative tax liability, and from a distributional perspective, restricting the credits to exclude taxpayers without tax liability decreases both horizontal and vertical equity.

A closely-related concern for the tax credits aimed at residential energy efficiency is that neither landlords nor renters are eligible. Principal-agent problems cause landlords to underinvest in energy-efficiency when their tenants pay the utility bill (Davis, 2012; Gillingham et al., 2012). As a consequence, there are investments in rental housing that have high private and social rate-of-return. Addressing this market failure is challenging because of imperfect information and split incentives, but excluding this sector altogether misses a large share of the housing stock and makes the credits more regressive.

Broadening the availability of these credits would make them more equitable and potentially more cost-effective. But it is also important to continue to emphasize the broader limitations with tax credits. One of the biggest limitations is that tax credits fail to account for heterogeneity in externalities. For example, it has been well documented that the Tesla Model S has become one of the most popular vehicles in the nation's highest-income zip codes.[7] But these tend not to be the locations where local pollutants from gasoline-powered cars are most damaging. External benefits vary widely across locations and adopters, depending on exactly which technology is being replaced, differences in usage, and other factors, yet none of this is captured by a uniform subsidy.

Allcott et al. (2015) discuss how targeting corrective subsidies toward individuals with larger distortions can increase welfare. In our context, this could include targeting electric vehicle tax credits for drivers living in more polluted cities, targeting solar panel tax credits for households living in places where daytime electricity generation comes from coal, or targeting energy-efficiency incentives for households living in homes with furnaces that use heating oil. These modifications would not make the tax credits equivalent to a first-best tax on externalities, but they could increase

[7]Caldwell, Jessica, "Drive by Numbers – Tesla Model S is the Vehicle of Choice in Many of America's Wealthiest Zip Codes," *Edmunds*, October 31, 2013.

efficiency.

At the same time, however, these tax credits are already complicated. The instructions are typically 3 to 4 pages long, involving separate worksheets and with references to multiple websites for additional information. This complexity adds administrative cost to the policies, both for taxpayers and for the taxing authority, and uncertainty for households who might like to make one of these investments, but are unsure exactly how these credits will affect their tax liability at the end of the year. One possibility that deserves additional consideration would be to provide these credits to firms rather than households. This could mean contractors, dealers, or retailers depending on the type of credit. Moving remittance upstream would reduce administrative costs both for households and for the IRS. It would also allow households to receive credits immediately, thereby reducing credit constraints.

## References


**Allcott, Hunt and Michael Greenstone**, "Is There an Energy Efficiency Gap?," *Journal of Economic Perspectives*, 2012, *26* (1), 3–28.

_ **, Christopher Knittel, and Dmitry Taubinsky**, "Tagging and Targeting of Energy Efficiency Subsidies," *American Economic Review Papers and Proceedings*, 2015.

**Bento, Antonio M, Lawrence H Goulder, Mark R Jacobsen, and Roger H Von Haefen**, "Distributional and Efficiency Impacts of Increased U.S. Gasoline Taxes," *American Economic Review*, 2009, *99* (3), 667–699.

**Boomhower, Judson and Lucas W Davis**, "A Credible Approach for Measuring Inframarginal Participation in Energy Efficiency programs," *Journal of Public Economics*, 2014, *113*, 67–79.

**Borenstein, Severin**, "The Private and Public Economies of Renewable Electricity Generation," *Journal of Economic Perspectives*, 2012, *26* (1), 67–92.

_ , "The Private Net Benefits of Residential Solar PV: And Who Gets Them," *Working Paper*, 2015.

_ **and Lucas W Davis**, "The Equity and Efficiency of Two-Part Tariffs in US Natural Gas Markets," *Journal of Law and Economics*, 2012, *55* (1), 75–128.

**Burtraw, Dallas, Richard Sweeney, and Margaret Walls**, "The Incidence of US Climate Policy: Alternative Uses of Revenues from a Cap-and-Trade Auction," *National Tax Journal*, 2009, *62* (3), 497–518.

**Chetty, Raj, John N Friedman, and Emmanuel Saez**, "Using Differences in Knowledge Across Neighborhoods to Uncover the Impacts of the EITC on Earnings," *The American Economic Review*, 2013, *103* (7), 2683–2721.

**_ , Nathaniel Hendren, Patrick Kline, and Emmanuel Saez**, "Where is the Land of Opportunity? The Geography of Intergenerational Mobility in the United States," *Quarterly Journal of Economics*, forthcoming.

**Crandall-Hollick, Margot L. and Molly F. Sherlock**, "Residential Energy Tax Credits: Overview and Analysis," *Congresssional Research Service*, 2014, *7-5700, R42089.*

**Davis, Lucas W**, "Evaluating the Slow Adoption of Energy Efficient Investments: Are Renters Less Likely to Have Energy Efficient Appliances?," in "The Design and Implementation of US Climate Policy," University of Chicago Press, 2012, pp. 301–316.

**Dubin, Jeffrey A and Steven E Henson**, "The Distributional Effects of the Federal Energy Tax Act," *Resources and Energy*, 1988, *10* (3), 191–212.

**Edenhofer, Ottmar, Ramón Pichs-Madruga, Youba Sokona, E Farahani, S Kadner, K Seyboth, A Adler, I Baum, S Brunner, P Eickemeier et al.**, "Climate Change 2014: Mitigation of Climate Change," *Working Group III Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, 2014.

**Fowlie, Meredith, Michael Greenstone, and Catherine Wolfram**, "Do Energy Efficiency Investments Deliver? Evidence from the Weatherization Assistance Program," *Working Paper*, 2015.

**Gallagher, K. and E. Muehlegger**, "Giving Green to Get Green? Incentives and Consumer Adoption of Hybrid Vehicle Technology," *Journal of Environmental Economics and Management*, 2011, *61* (1), 1–15.

**Gillingham, Kenneth, Matthew Harding, David Rapson et al.**, "Split Incentives in Residential Energy Consumption," *Energy Journal*, 2012, *33* (2), 37–62.

**Hassett, Kevin A and Gilbert E Metcalf**, "Energy Tax Credits and Residential Conservation Investment: Evidence from Panel Data," *Journal of Public Economics*, 1995, *57* (2), 201–217.

**_ , Aparna Mathur, and Gilbert E Metcalf**, "The Incidence of a U.S. Carbon Tax: A Lifetime and Regional Analysis," Technical Report, National Bureau of Economic Research 2007.

**Holland, Stephen P, Erin T Mansur, Nicholas Z Muller, and Andrew J Yates**, "Measuring the Spatial Heterogeneity in Environmental Externalities from Driving: A Comparison of Gasoline and Electric Vehicles," 2014.

**Hughes, Jonathan E and Molly Podolefsky**, "Getting Green with Solar Subsidies: Evidence from the California Solar Initiative," *Journal of the Association of Environmental and Resource Economists*, forthcoming.

**Kahn, Matthew E**, "Do Greens Drive Hummers or Hybrids? Environmental Ideology as a Determinant of Consumer Choice," *Journal of Environmental Economics and Management*, 2007, *54* (2), 129–145.

**Mian, A. and A. Sufi**, "The Effects of Fiscal Stimulus: Evidence from the 2009 Cash for Clunkers Program," *Quarterly Journal of Economics*, 2012, *127* (3), 1107–1142.

**Neveu, Andre R and Molly F Sherlock**, "An Evaluation of Tax Credits for Residential Energy Efficiency," *Eastern Economic Journal*, forthcoming.

**Piketty, Thomas and Emmanuel Saez**, "Inequality in the Long Run," *Science*, 2014, *344* (6186), 838–843.

**Poterba, James M**, "Lifetime Incidence and the Distributional Burden of Excise Taxes," *The American Economic Review*, 1989, pp. 325–330.

_ , "Is the Gasoline Tax Regressive?," in "Tax Policy and the Economy, Volume 5," The MIT Press, 1991, pp. 145–164.

**Rausch, Sebastian, Gilbert E Metcalf, and John M Reilly**, "Distributional Impacts of Carbon Pricing: A General Equilibrium Approach with Micro-data for Households," *Energy Economics*, 2011, *33*, S20–S33.

**Sallee, James M**, "The Surprising Incidence of Tax Credits for the Toyota Prius," *American Economic Journal: Economic Policy*, 2011, *3* (2), 189–219.

**West, Sarah E**, "Distributional Effects of Alternative Vehicle Pollution Control Policies," *Journal of Public Economics*, 2004, *88* (3), 735–757.

# A Data Description

For the distributional analysis we compiled data from three different sources, all based on tax returns filed with the U.S. Department of Treasury, Internal Revenue Service (IRS). Most of our data comes, in one form or another, from the IRS' *Statistics of Income* (SOI) program, a federal statistical organization that gathers, analyzes, and publishes information about U.S. income taxes.[8]

## A.1 Summary Statistics

The first data source is a series of annual reports from the IRS' SOI program which publish summary statistics for all different categories of income tax credits.[9] These data report the total number of returns and total dollar value of the credit by income category. Statistics are reported for 19 or 20 different categories (depending on the year) of adjusted gross income ranging from $0 to $10,000,000+. In many of our analyses we collapse these categories into approximate quintiles to make the evidence easier to interpret.

These summary statistics are calculated by the IRS based on large representative samples drawn from the 140+ million individual income tax returns filed each year. The underlying samples included, for example, 308,000 returns in 2010 and 330,000 returns in 2011.[10] The IRS reports standard errors for all summary statistics, expressed as a percentage of the statistic being estimated. Where appropriate, we use these standard errors to construct 95th percentile confidence intervals. In general, the sampling variation is modest for our main results, (e.g. Figure 5), but larger and more important to account for when we report results separately by year and credit category in Figures B1, B2, and B3.

[8] SOI data are made available online in a variety of different formats. See `http://www.irs.gov/uac/Tax-Stats-2` for general information and `http://www.irs.gov/uac/SOI-Tax-Stats-Individual-Income-Tax-Return-Form-1040-Statistics` for information specifically about the individual income tax.

[9] See, e.g, U.S. Department of the Treasury, Internal Revenue Service, "Individual Tax Returns 2012", Publication 1304, Washington, D.C.. Accessed online at, `http://www.irs.gov/pub/irs-soi/12inalcr.pdf`. We used, in particular in Table 3.3 " All Returns: Tax Liability, Tax Credits, and Tax Payments, by Size of Adjusted Gross Income".

[10] U.S. Department of the Treasury, Internal Revenue Service, "Statistics of Income Bulletin", Fall 2012 (p.21) and Fall 2013 (p. 21).

## A.2 Line Item Estimates

The second data source is a different series of annual reports from the IRS' SOI program which provide frequencies and amounts for individual line items.[11] These reports go line-by-line through the 1040 and accompanying schedules and subforms, providing for each line an estimate of the number of filers that included a number in the line, and the sum of all values recorded by all filers. This line item information is estimated using the same large representative samples used by SOI to calculate the summary statistics.

These data are a valuable complement to the first data source because they include additional detail that is not available elsewhere. Taxpayers who claim the NEPC or REEPC are required to file Form 5695 "Residential Energy Credits" along with their 1040, but only the total dollar amount from the 5695 is described in the SOI summary statistics. The line item estimates, however, provide line-by-line information. For example, with the REEPC, these data allows us to determine for Table B1 how much of the credit went to photovoltaic systems, geothermal heat pumps, and solar water heating systems. For the NEPC, these data allow us to distinguish between energy-efficient windows, qualified furnaces and boilers, and the other categories of energy-efficiency improvements.

## A.3 Public Use Microdata

The third data source is income tax return microdata from the Public Use Tax Files.[12] We have not yet incorporated these data into our analysis but intend to do so during Spring 2015. These data are a large representative sample U.S. income tax returns. Public use microdata have been available since 1960 but in the analyses which plan to focus on 2005–2008.[13]

Individual identifiers, like name and address, are removed and some variables like alimony paid or received are rounded or "blurred" to prevent the identification of individual taxpayers. In addition, the state of residence is removed for records with $200,000+ adjusted gross income. There are about 140,000 tax returns for each year. These records are a stratified sample of all returns processed during that

[11] See, e.g., U.S. Department of the Treasury, IRS, "Individual Income Tax Returns Line Item Estimates, 2012", Publication 4801, Washington, D.C.. Accessed online at, `http://www.irs.gov/uac/SOI-Tax-Stats-Individual-Income-Tax-Returns,-Line-Item-Estimates`.

[12] See., e.g., See, e.g., U.S. Department of the Treasury, IRS, "General Description Booklet for the 2008 Public Use Tax File", Washington, D.C., November 2012. We will access these data at the National Bureau of Economic Research and are thankful to Daniel Feenberg for his helpful guidance with these data.

[13] We hope to incorporate data from 2009 when these data become available. There is approximately a five year delay before each dataset is released.

year. For example, the 139,651 records in the 2008 Public Use data were drawn from the universe of 142+ million returns processed during 2009. The sampling rate varies substantially across strata but, overall, represents about 1 in every 1000 tax returns.[14]

The microdata provide some, but not all of the detailed information from the individual returns. In particular, the microdata includes the total dollar amount of "Residential Energy Credits", as reported on the main 1040 form, but not separate dollar amounts for the REEPC and the NEPC. Although separate dollar amounts are not recorded, it will be reasonably straightforward to determine which taxpayer received which credit. In 2008 the NEPC was not available, so all credits for that year can be assumed to be for the REEPC. Moreover, for years in which both credits were available we plan to distinguish between the NEPC and REEPC using the fact that the typical credit amounts are very different in the two programs. In particular, the NEPC tends to be a much more modest credit, capped at $500 in most years, whereas the REEPC is much more generous as we show in Table B1. The microdata do not include information on the AMVC or the PEDVC. Both vehicle credits are reported on a single line in the 1040 form "other credits", along with several other credits, and only this total amount is included in the microdata.

Despite these important limitations, the microdata offer a couple of important advantages relative to the two other data sources. The microdata provide the exact adjusted gross income for each return, allowing us to more accurately describe the distribution of income across credit recipients. In addition, being able to distinguish between the NEPC and REEPC will allow us to plot Lorenz curves and calculate Gini coefficients for these two tax credits separately. More importantly, the microdata will allow us to examine additional socioeconomic characteristics like homeownership, number of dependents and state of residence. Finally, we plan to use the microdata to determine how important it is that these credits are non-refundable, and to examine the interaction between these credits and the Alternative Minimum Tax.

## A.4 Additional Description of Tables and Figures

Table 1 reports annual expenditures on U.S. clean energy tax credits between 2005 and 2012. For each year we report total expenditures (in millions) for each of the

[14]The full population of tax returns is not publicly available, but under some circumstances researchers have contracted with the IRS to access their entire "Compliance Data Warehouse". These data have their own challenges, but are indispensable for studies aimed at, for example, comparisons across cities Chetty et al. (forthcoming). These data also include "information returns" i.e. W-2 forms for individuals who don't file a return so are valuable for studying the EITC and other interventions aimed at taxpayers close to the margin between filing and not filing a return (Chetty et al., 2013).

different clean energy tax credits. The line item estimates were used to construct expenditure levels for the NEPC and REEPC, which otherwise are not reported separately in the IRS' "Individual Income Tax Returns".

Table 2 describes the distributional effects of selected tax credits. Columns (1)–(6) report the percentage of total credit dollars received by tax filers in each of six categories of Adjusted Gross Income (AGI). That is, for each income category, we calculate the total amount of credit received by filers in that category between 2005 and 2012, and divide by the total credit received by all filers in all income categories. The last column reports the Gini coefficient for each credit. We calculate the Gini coefficients much like we calculate percentages received by income category, pooling credit receipts and AGI across all years for which each credit was available. The IRS' "Individual Income Tax Returns" report the NEPC and the REEPC together as "Residential Energy Credits," so we cannot examine the distributional effects of these two credits separately.

Table B1 reports tax expenditures and ond other statistics by category. For the NEPC and REEPC this includes the different categories of qualified investments, which we characterized as accurately as we could based on the longer descriptions in the tax code. No such categories are available for the AMVC and REEPC, but for completeness we include these credits as well and report the number of filers claiming the credit and average credit claimed.

For each credit, Column (1) reports total tax expenditures between 2005 and 2012 by category. Column (2) reports the percentage of total credit amount of each credit that was claimed for each category. Column (3) reports the total number of tax returns that had eligible expenditures in a given category during the period 2005 to 2012. Taxpayers can claim expenses in multiple categories, so these are not mutually exclusive. Finally, Column (4) is the average credit amount claimed in each category, which we calculate by dividing column (1) by column (3). Notably, the average credit claimed for fuel cell systems is smaller than the other categories because there is a per-kilowatt cap that only applies to this category.

The line item data show total reported expenditures by category, without regard to whether claimants were above the maximum credit amount, and thus ineligible to receive the credit on the entire dollar amount. For example, in 2006 the NEPC was a 10% credit for most types of expenditures with a maximum total credit of $500, so taxpayers received the credit only for the first $5000 of expenditures. Consequently, total reported expenditures in the line item data exceeds actual tax expenditures for each credit, which are reported in the IRS' "Individual Income Tax Returns" reports. In practice, the former exceeds the latter by less than 20% on average. In calculating the dollar values for Table 2, we scaled down each category proportionally.

This scaling affects the estimates of total expenditure by category and average credit claimed, but not the *percentage* of expenditure by category or the number claiming credit.

Another complication in calculating the exact expenditure amounts by category is that with the REEPC, taxpayers with zero tax liability may carry any unused portion of the tax over to future tax years. With the aggregate data we are not able to track these carryovers so we assume that any credits that are carried over are divided across the expenditure categories in the same proportion as new expenditures in that tax year.

Oddly, the IRS' SOI publications do not provide the number of returns claiming the AMVC, nor the total amount of the AMVC claimed, by income category in 2006. Thus, for tax year 2006 data we use the AMVC totals from the IRS SOI complete report table 1.3, "All Returns: Sources of Income, Adjustments, Deductions, Credits, and Tax Items" in table B1.

Figures B4 and B5 plot the share of returns claiming each credit and the average credit amount claimed by AGI bin. We calculate these statistics only over the years for which each credit is available as indicated in the panel headings. Because AMVC statistics were not published in 2006, we report statistics for the AMVC for 2007-2013. The PEDVC started in 2009 so we report statistics for 2009-2012. For average credit amount claimed the 95th percentile confidence intervals tend to be quite wide for the AMVC and PEDVC, particularly for the lowest-income quintiles.

Figures 5, B4, B5, B1, B2 and B3 plot 95% confidence intervals around the estimates of the value at each bin. These confidence intervals were calculated by the authors using the coefficients of variation reported in the IRS' "Individual Income Tax Returns". In particular, for each estimate the IRS reports the ratio of the standard error of the estimate to the estimate itself.

# B Supplementary Figures and Tables

Table B1: Tax Expenditures By Category, 2005–2012

| Category | Total Expenditure, in Millions | Percentage of Total Credit | Number Claiming Credit, in Thousands | Average Credit Claimed |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Panel A. Nonbusiness Energy Property Credit (NEPC) | | | | |
| Energy-Efficient Windows | $4004 | 29.3% | 9636 | $415 |
| Qualified Furnaces and Boilers | $2440 | 17.8% | 5937 | $411 |
| ACs, Water Heaters, etc. | $2375 | 17.4% | 4635 | $512 |
| Ceiling and Wall Insulation | $2020 | 14.8% | 8433 | $239 |
| Energy-Efficient Doors | $1336 | 9.8% | 7868 | $170 |
| Qualified Reflective Metal Roofs | $1120 | 8.2% | 1578 | $710 |
| Qualified Circulation Fans | $393 | 2.9% | 1162 | $339 |
| Panel B. Residential Energy Efficiency Property Credit (REEPC) | | | | |
| Photovoltaic Systems | $1848 | 53.4% | 347 | $5323 |
| Geothermal Heat Pumps | $1200 | 34.7% | 317 | $3784 |
| Solar Water Heating Systems | $350 | 10.1% | 303 | $1155 |
| Wind Turbines | $52 | 1.5% | 48 | $1073 |
| Fuel Cell Systems | $12 | 0.3% | 31 | $378 |
| Panel C. Alternative Motor Vehicle Credit (AMVC) | | | | |
| – | $549 | – | 372 | $1476 |
| Panel D. Qualified Plug-in Electric Drive Motor Vehicle Credit (PEDVC) | | | | |
| – | $346 | – | 60 | $5755 |

Note: This table was constructed by the authors using U.S. Department of the Treasury, Internal Revenue Service, "Statistics of Income Bulletin," 2005–2012 and U.S. Department of the Treasury, Internal Revenue Service, "Individual Income Tax Returns Line Item Estimates," 2005–2012. See Appendix A for details.

Figure B1: Average Credit Per Return for Residential Energy Credits

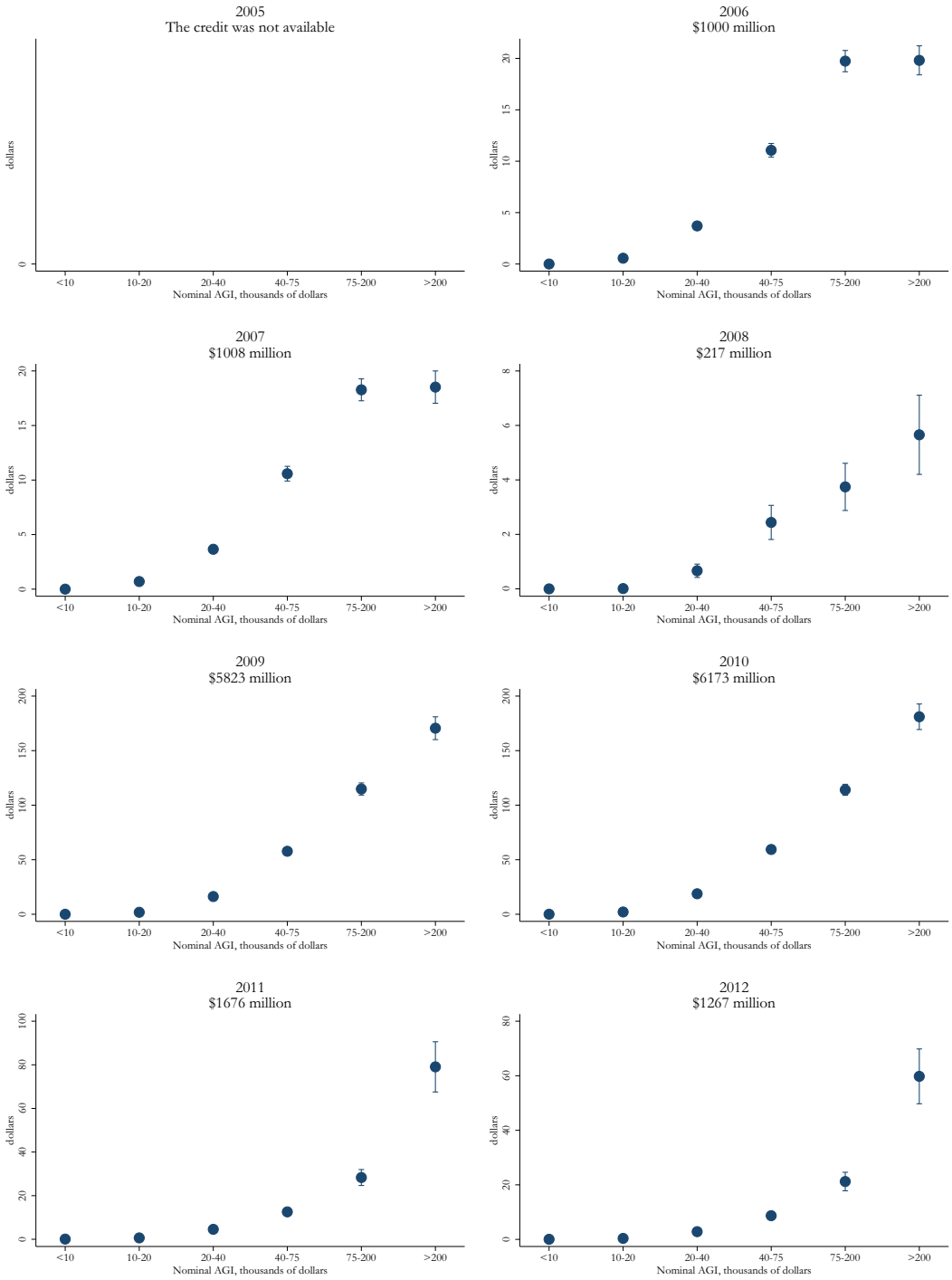


Figure B2: Average Credit Per Return for Alternative Motor Vehicle Credit

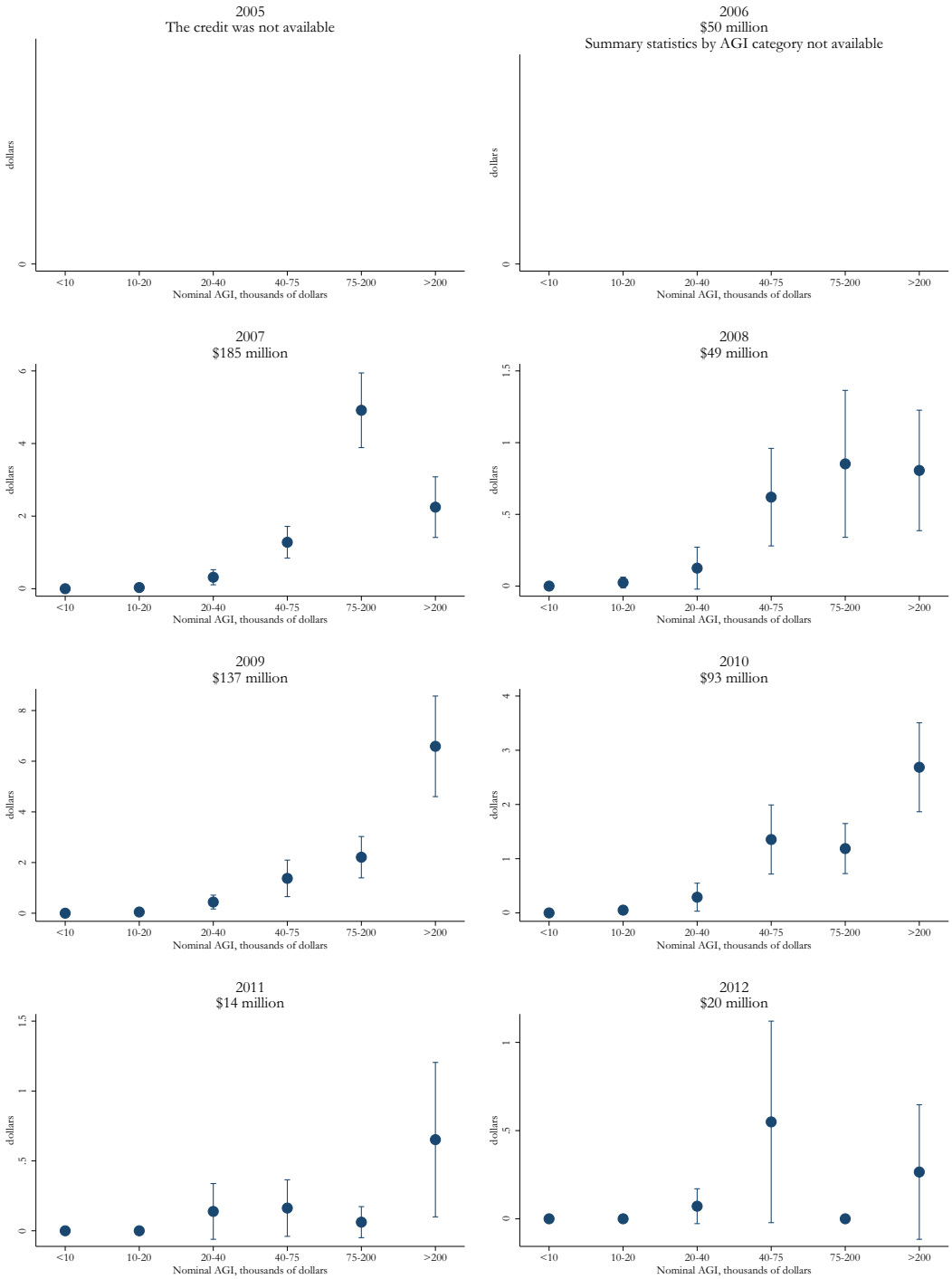


Figure B3: Average Credit Per Return for Plug-in Electric Drive Vehicle Credit

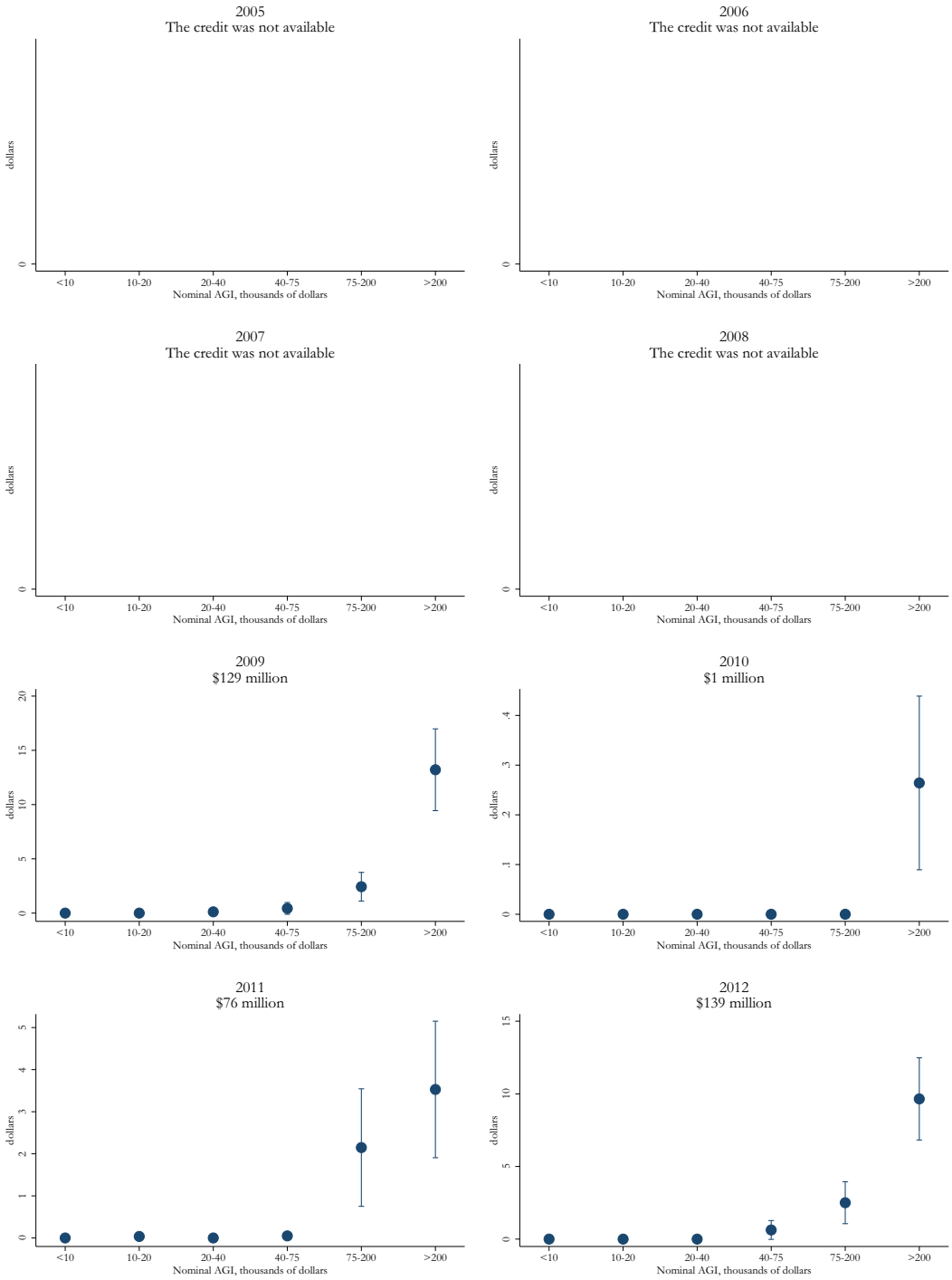
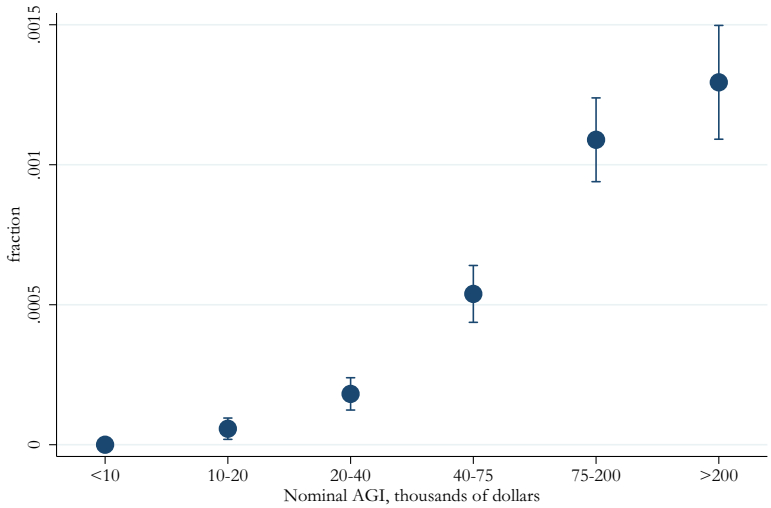


Figure B4: Share Claiming Credit by Adjusted Gross Income

A: Alternative Motor Vehicle Credit, 2007-2012




B: Qualified Plug-in Electric Drive Motor Vehicle Credit, 2009-2012

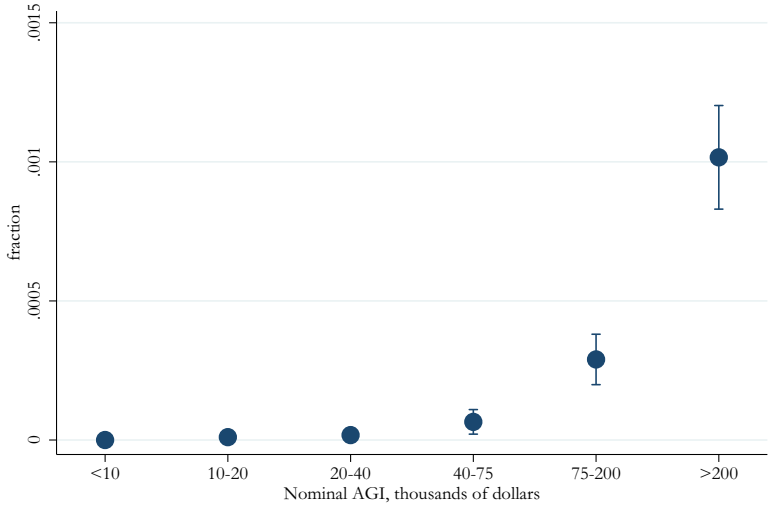
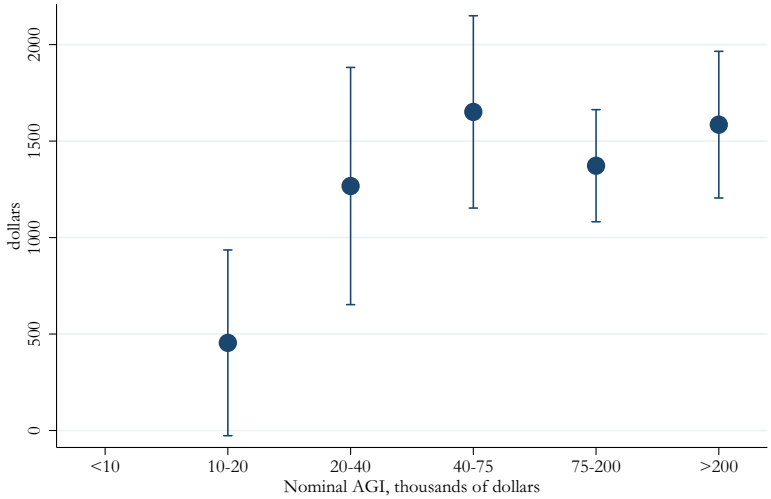


Figure B5: Average Credit Amount Claimed by Adjusted Gross Income

A: Alternative Motor Vehicle Credit, 2007-2012




B: Qualified Plug-in Electric Drive Motor Vehicle Credit, 2009-2012

