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The Implied Cost of Carbon Dioxide under the Cash for Clunkers Program

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Abstract

The Cash for Clunker program aims to stimulate the economy, provide relief for automobile manufacturers and reduce greenhouse gas emissions. In this research note, I present estimates of the implied cost of carbon dioxide reductions under the Cash for Clunker program. The estimates suggest that the program is an expensive way to reduce greenhouse gases. This is true under a wide range of assumptions regarding the increase in fuel economy of new vehicles purchased under the program, how long the clunkers would have been on the road if not for the program, and whether we account for reductions in criteria pollutants. Conservative estimates of the implied carbon cost exceed $365 per ton; best case scenario parameter values suggest a cost of carbon of $237 per ton.

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1 Introduction

The "Cash for Clunker" (CfC) program aims to stimulate the economy, provide relief for automobile manufacturers and reduce greenhouse gas emissions. In this short note, I make back of the envelope calculations of the implied cost of carbon under the program. The results suggest that the program is an expensive way to reduce carbon; this remains true when we account for reductions in criteria pollutants. Reasonable parameter values suggest an implied carbon cost in excess of \$500 per ton; best case scenario parameter values suggest a cost of carbon of \$237 per ton.

The reason for these results is easy to understand. Imagine a CfC program with a \$4500 rebate. Suppose the driving habits of both the clunkers and new cars are same, say an annual vehicle miles travelled of 12,000 miles. If the clunker's fuel economy is 16 mpg, while the new car's fuel economy is 25 mpg, then the scrappage program saves 270 gallons for every year the clunker would have been on the road. When burned, a gallon of gasoline creates roughly 20 pounds of carbon dioxide.[1] Therefore, the program saves 2.7 tons of carbon dioxide each year the clunker would have survived. If the clunker would have survived another four years, the program has saved 10.8 tons of carbon dioxide for \$4,500, or an average cost of over \$400 per ton.

In this note I discuss and show how expanding on this simple example changes the cost estimates. For example, the car may have survived for a longer, or shorter, time period. The new vehicle might be driven more than the clunker. Or, we may want to account for reductions in other pollutants.

I do not discuss the merits of the program in terms of stimulus. While the program is an expensive way to reduce greenhouse gases, it is certainly possible that the stimulus benefits outweigh the added environmental costs. I leave this question for a broader analysis of the program, but note that key legislators have suggested that the environmental gains from the program are large.

2 Model Set Up

An ideal investigation of the cost effectiveness of the program would calculate the amount of carbon that would be emitted absent the program and compare it to the amount of carbon that will be

[1] Throughout the paper, I use greenhouse gases and carbon dioxide interchangeably, but note that automobile air conditioning systems emit other greenhouse gases.

emitted with it.. Given that a gallon of gas creates roughly 20 pounds of CO_2 when burned, the amount of carbon saved by the program, in tons, is given as:

$$GHGsavings = \frac{1}{100} \cdot \sum_{i=1}^{N} \sum_{t=1}^{T} (gallons/mile_{itc} \cdot miles_{itc} - gallons/mile_{itn} \cdot miles_{itn}) \quad (1)$$

where c represents the clunker, n the new car and i indexes the consumers taking advantage of the program. The second summation sums the difference in annual greenhouse gas emissions over the life of the clunker.[2] Ideally, we would know the joint distribution of the variables in equation (1), since the the four variables are unlikely to be independent. For example, those consumers choosing more fuel efficiency may do so because they drive more.

Absent the full distribution, as well as information about future driving habits and the unobserved mileage of the clunker had CfC not existed, I use simple means of the variables in equation 1. I assume a variety of values for the increased speed with which the clunker is scrapped.

According to a recent CNN report, the average mileage of clunkers was 16.3 mpg; the average mileage of new cars purchased under the program was 24.8 mpg.[3] As a starting point, I assume that the clunker would have been driven 12,000 miles. I begin using the most conservative assumption that the new car is driven the same amount as the clunker.

There are at least three reasons to believe that the new vehicle will be driven more miles than the clunker. First, there is the classic "rebound" effect. Given the increase in fuel efficiency of the new car, the marginal cost of driving is lower. Second, numerous reports suggest that consumers are trading vehicles that were not being used.[4] Third, the new vehicle is likely to be more comfortable, also reducing the marginal cost of driving.

Estimates of the rebound effect exist. Small and van Dender (2007) estimate a long run rebound elasticity of 0.11 over the period of 1997 to 2001. In section 3, I vary the rebound/adverse selection parameter.

[2]This makes at three simplifications. First, there is no discounting. Second, this assumes that the consumer would have purchased a vehicle with the same fuel economy at time T that she purchased under the CfC program. Third, it ignores the greenhouse gases emitted from the manufacturing of the new car and the scrapping of the clunker. See, Allan, Carpenter and Morrison (2008) for an analysis of these emissions.

[3]http://wheels.blogs.nytimes.com/2009/08/04/cash-for-clunkers-by-the-numbers/

[4]See, for example, http://blogs.consumerreports.org/cars/2009/07/cash-for-clunkers-government-stalls-the-cars-program.html

Under these assumptions, if the clunker is taken off of the road four years earlier because of the program, then the CfC program saves 7.57 tons of carbon per sale.[5] Assuming an average rebate of $4200, this implies an average cost of carbon of $416 per ton (reported in Table 2).[6] If we increase the length the clunker would have been on the road to five years, the implied cost of carbon is $333. If this is reduced to three years, the implied cost is $556.

Another way to interpret the savings in greenhouse gases is to ask how much more fuel efficient would the new vehicles have to be for the program to be cost effective? The CBO recently projected the allowance prices under the Waxman-Markey cap and trade program would be $28 per ton. At any reasonable scrappage rate, the cost per carbon under the CfC program exceeds this tenfold. Indeed, even if the new cars were greenhouse gas free, the clunkers would have had to have been driven 12,000 mile per year for over 20 years if not for the CfC program. This is not surprising once the simple calculations are done. At 16.3 miles per gallon, driven 12,000 miles, the clunkers consume 736.20 gallons per year, thereby emitting 7.36 tons of carbon dioxide per year. At an average CfC rebate of $4,200, the program must save 150 tons per vehicle to have an implied carbon price of $28. Once the greenhouse gases of the new vehicles are considered, the clunkers would have had to have been on the road for nearly 60 years, even with no rebound or adverse selection.

3 Alternative Parameter Values

3.1 Varying the Scrappage Rate

I previously reported results assuming that the clunkers are taken off of the road either three, four, or five years earlier due to the program. The longer the clunkers would have stayed on the road, the more cost effective the policy. Figure 1 plots the implied carbon cost allowing the clunker to have stayed on the road up to tens years and setting the other parameters at their "base" levels.[7] Even if the program takes vehicles that would have continued to have been driven 12,000 miles per year for 10 additional years, the implied carbon price is over $200 per ton.

[5] The spreadsheet used to make all of the calculations in this note is available at: http://www.econ.ucdavis.edu/faculty/knittel/CfC.xls

[6] Consumer report estimates the average rebate to be $4215. http://blogs.consumerreports.org/cars/2009/07/cash-for-clunkers-government-stalls-the-cars-program.html

[7] This does not "discount" the CO2 reductions in any way.

What are reasonable estimates of the number of years the clunker would have been on the road? I use estimates from Lu (2006) for guidance. Lu estimates survival rates and vehicle miles travelled across vehicle vintages for both cars and light trucks. Ideally, we would have information about the distribution of clunkers under the program to calculate trade-in specific estimates of the miles the car was likely to have driven and its survival. Even this, however, would not be ideal since those vehicles traded in are likely to have been driven more miles than the average vehicle of their age.

From the survival probabilities, if we assume independence of the hazard rates across years, we can calculate the expected life of a vehicle, conditional on surviving a certain time period. If we use the average age of trade-ins under the program, between 13 and 14 years, then the expected number of years a car would have stayed on the road is 3.5 year, for trucks this is 7.5 years. This calculation suggests the reduction in the life of the average vehicle in the program is roughly five years. However, if we include information about the driving habits of these vehicles, five years is likely too long of a “credit”. The expected number of miles a 13 year old car will travel is 30,300. The expected number of miles a 13 year old truck will travel is 63,400. The average of these two is 45,000, or roughly 4 years at 12,000 miles per year.[8] For this reason, I use four years as my preferred parameter value.

3.2 Varying Rebound/Adverse Selection Parameter

The base set of results assumes that vehicle miles travelled (VMT) of new cars purchased under the program does not increase, despite the increase in fuel economy and any adverse selection effects. Figure 2 plots the implied carbon prices allowing this parameter to range from zero to 0.50, under three, four and five years of scrappage. Table 2 reports results assuming rebound elasticities of 0.1, 0.25, and 0.5. As a frame of reference, at a rebound elasticity of 0.5, implying the new car is driven 3,129 more miles than the clunker, the implied carbon costs are $832 per ton for a four year scrappage increase.

What is the preferred estimate? Ideally, we would know the miles the clunker would have been driven and compare this to the miles the new car will be driven to calculate greenhouse gas savings. This information obviously does not exist. Again, the calculations in Lu (2006) provide some guidance. For the greenhouse gas savings what matters is the total miles driven by the new and the clunker. Again, the calculations in Lu suggest that a 13-year-old car will be driven for

[8] I do not have information on the fraction of cars and trucks being traded in.

3.5 years with an expected VMT of 30,300 miles. At the average mpg of clunkers, this implies 1,859 gallons of gas consumed. In the first 3.5 years of a new car, the expected VMT is 47,726. At the average mpg of new cars, this implies a total consumption of 1,924 gallons of gasoline. These calculations imply an increase in greenhouse gases. A similar story exists for trucks. The expected VMT of a 13-year-old truck is 63,400. At the average mpg of clunkers (which, unfortunately, is the average across cars and trucks), the clunker would consume 3,890 gallons of gasoline. A new light truck, driven for 7.5 years, has an expected VMT of 101,704, thereby consuming 4,104 gallons.[9]

There are many reasons to think that the increase in VMT will not be so extreme as to raise greenhouse gases from the program, but these calculations at least suggest that it is possible. For example, a family of three may trade in their teenager's car, that was being driven only 6,000 miles, and purchase a new car that will primarily be driven by one of the parents, shifting the parent's previous car to the teenager. Under this scenario aggregate VMT may not increase. However, the reductions in fuel consumption are uncertain since, while the teenager's "new" car is more fuel efficient than her previous car, the parent's new car may not be.

It is, however, unlikely that VMT will *fall* due to the program. Given this, we can continue to view the zero rebound results as representing conservative estimates of the implied carbon price of the program. But, it would seem that moderate increases in VMT are equally, if not more, likely than no increase.

3.3 Accounting for Co-benefits from Criteria Pollutants

Automobiles not only emit greenhouse gases, but they also emit criteria pollutants—pollution that causes more localized health and environmental damage. In particular, cars emit nitrogen oxides, hydrocarbons, particulate matter and carbon monoxide. New cars purchased under the program are not only more fuel efficient, but they are also cleaner in terms of criteria pollutants. This is due in large part to state and federal standards regulating the amount of these pollutants that can be emitted on a grams per mile basis.

To account for these reductions, I subtract the social benefits from criteria pollutant reductions from the implied carbon price. This requires assumptions regarding how much cleaner the new

[9] This accords with a recent Consumer Reports article polls participants in the program and finds that the average clunker was driven only 6,000 miles in the previous year. http://blogs.consumerreports.org/cars/2009/07/cash-for-clunkers-government-stalls-the-cars-program.html

cars are, relative to the clunkers, and the social costs of these emissions. The average age of the clunkers is between 13 and 14 years old. As a conservative estimate of the average criteria pollutant emissions of clunkers, I use the Federal standards for NOx, VOCs, PM10 and CO in 1990. For NOx, this standard began in 1988; the VOC standard began in 1984, PM10 in 1987 and CO in 1984. Therefore, these are close to the best case scenarios since vehicles with models years older than 1983 do not qualify for the program. For new cars, I use the current standards.

I use the expected marginal social damages for NOx, VOCs and PM10 from Muller and Mendelsohn (forthcoming). For CO, McCubbin and Delucchi (1994) report a cost per kilogram ranging from 0.01 to 0.09, in 1990 dollars. This implies a cost per ton of between $15 and $134 in 2009 dollars. I use the average of this range.

Cash for Clunkers remains an expensive way to reduce greenhouse gases even when we "credit" for criteria pollutants. Table 2 reports the results using the parameters from the base case. The implied cost of carbon is $516, $365 and $269 for three, four and five year scrappage time, respectively. If we increase the social costs of each pollutant by 50 percent, the implied cost of carbon remains above $237 per ton. This is the lower bound of the estimates in this note.

4 Conclusions

The Cash for Clunker program is both a stimulus and environmental program. In this note, I calculate the implied cost of greenhouse gas emission reductions and find that they exceed those estimates from the Waxman-Markey bill by nearly tenfold.

References

[1] Allan, Alexander, Rachael Carpenter and Geoff Morrison. "Abating Greenhouse Gas Emissions through Cash-for-Clunker Programs," mimeo UC Davis.

[2] Lu, S. "Vehicle Survivability and Travel Mileage Schedules," NHTSA Technical Report, DOT HS 809 952, (2006).

[3] McCubbin, R. and M. A. Delucchi. "The Health Costs of Motor-Vehicle Related Air Pollution," Journal of Transport Economics and Policy 33: 253-286 (1999).

[4] Muller, N. Z. and R. O. Mendelsohn. "Efficient Pollution Regulation: Getting the Prices Right,"The American Economic Review, forthcoming.

[5] Small, Kenneth and Kurt van Dender. "Fuel Efficiency and Motor Vehicle Travel: The Declining Rebound Effect," Energy Journal, 28 (2007), pp. 25-51.

5 Tables

	Cost of Carbon Dioxide (per ton)		
	Three Years	Four Years	Five Years
Base Case	$ 556	$ 416	$ 333
Rebound elasticity of 0.10 (636 mile increase)	$ 616	$ 462	$ 370
Rebound elasticity of 0.25 (1,564 miles increase)	$ 740	$ 535	$ 444
Rebound elasticity of 0.50 (3,129 mile increase)	$ 1,110	$ 832	$ 666
Accounting for for Criteria Pollutants	$ 516	$ 365	$ 269
Accounting for for Criteria Pollutants with rebound elasticity of 0.10	$ 579	$ 412	$ 307
Accounting for for Criteria Pollutants with rebound elasticity of 0.25	$ 703	$ 506	$ 383
Accounting for for Criteria Pollutants with rebound elasticity of 0.50	$ 1,075	$ 786	$ 608
50% increase in Social Cost of Criteria Pollutants	$ 497	$ 339	$ 237

Table 1: Cost of Carbon Estimates

	Cars		Light Trucks	
Vintage	**Survival Probability**	**VMT**	**Survival Probability**	**VMT**
1	0.9900	14,231	0.9741	16,085
2	0.9831	13,961	0.9603	15,782
3	0.9731	13,669	0.9420	15,442
4	0.9593	13,357	0.9190	15,069
5	0.9413	13,028	0.8913	14,667
6	0.9188	12,683	0.8590	14,239
7	0.8918	12,325	0.8226	13,790
8	0.8604	11,956	0.7827	13,323
9	0.8252	11,578	0.7401	12,844
10	0.7866	11,193	0.6956	12,356
11	0.7170	10,804	0.6501	11,863
12	0.6125	10,413	0.6040	11,369
13	0.5094	10,022	0.5517	10,879
14	0.4142	9,633	0.5009	10,396
15	0.3308	9,249	0.4522	9,924
16	0.2604	8,871	0.4062	9,468
17	0.2028	8,502	0.3633	9,032
18	0.1565	8,144	0.3236	8,619
19	0.1200	7,799	0.2873	8,234
20	0.0916	7,469	0.2542	7,881
21	0.0696	7,157	0.2244	7,565
22	0.0527	6,866	0.1975	7,288
23	0.0399	6,596	0.1735	7,055
24	0.0301	6,350	0.1522	6,871
25	0.0227	6,131	0.1332	6,739
26			0.1165	6,663
27			0.1017	6,648
28			0.0887	6,648
29			0.0773	6,648
30			0.0673	6,648
31			0.0586	6,648
32			0.0509	6,648
33			0.0443	6,648
34			0.0385	6,648
35			0.0334	6,648
36			0.0290	6,648

Table 2: Survival and VMT by Vintage

6 Figures

Figure 1: Varying the Scrappage Rate

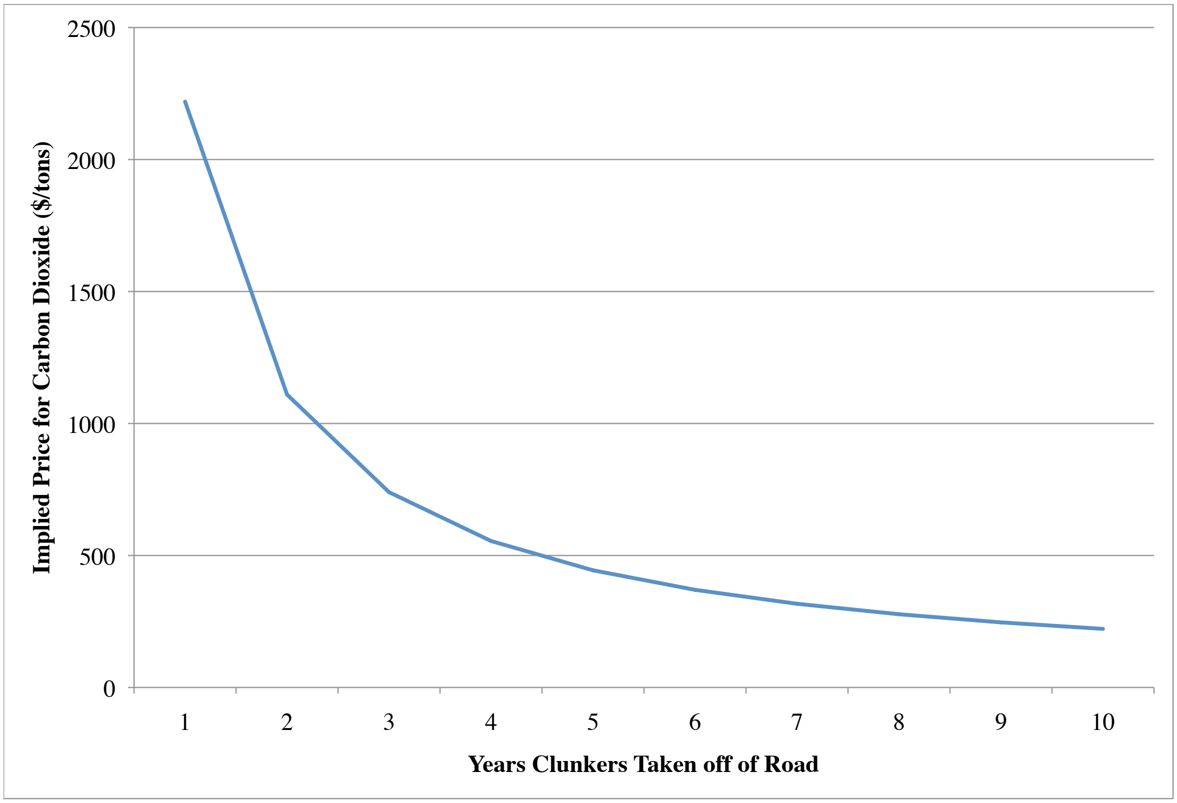

Figure 2: Varying the Rebound/Adverse Selection Elasticity