

Tradable Fuel Economy Credits

Analysis and Text Extended from Chapter 5 of
Impact and Effectiveness of Corporate Average Fuel Economy Standards
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The existing CAFE system already allows a manufacturer to accumulate CAFE credits if its fleet mix exceeds the standard. These credits may be carried forward and used to offset future CAFE deficits by the same manufacturer. The idea of “tradable fuel economy credits,” or “tradable credits,” carries this flexibility one step further: manufacturers could also be allowed to sell and buy credits among themselves or to buy credits from the government.

Under this system, fuel economy targets would be set, either uniform targets as in the current CAFE system, or attribute-based targets. Each manufacturer would be required either to meet these targets as a corporate average of new vehicle sales, or to acquire sufficient credits to make up the deficit. The credits could be purchased from the government or from other automobile manufacturers. A manufacturer whose new vehicle fleet had greater fuel economy than the overall target would acquire credits. These credits could be saved for anticipated later deficits or could be sold to other manufacturers.

Credit for a given make and model of a vehicle would be equal to the difference between the projected lifetime gasoline use of vehicles just meeting the target and the projected gasoline use over the life of that vehicle, using a legislatively deemed total lifetime vehicle miles. The projected lifetime gasoline use of vehicles just meeting the target would be the ratio of the deemed total lifetime vehicle miles and the target mpg for the class of vehicles. Likewise, the projected lifetime gasoline use would be the ratio of the deemed total lifetime vehicle miles and the actual mpg of the make and model of vehicle. If the target mpg is greater than the actual mpg, the difference will be a negative number, or a deficit for that vehicle make and model. If the target mpg is smaller than the actual mpg, the difference will be a positive number, or a credit for that vehicle make and model.

The total credits (or deficits) for a manufacturer are calculated by determining the credit or deficit for each vehicle make and model, multiplying by the number of vehicles of that make and model sold, adding up the credits across all makes and models, and subtracting the sum of deficits across all makes and models.

The total credits or deficits could be calculated in a second way, a way that is mathematically equivalent. The manufacturer could calculate a weighted average of target gallons per mile for the various makes and models of vehicles. From that weighted average would be subtracted the weighted average of actual gallons per mile across all makes and models of vehicles. Weights would correspond to the fraction of the manufacturers sales accounted for by each make and

model. The difference would be multiplied by the deemed total lifetime vehicle miles and that product would be multiplied by the total number of vehicles sold. If the difference is positive, the manufacturer would have a credit; if negative, the manufacturer would face a deficit. Whether the averaging is done first and the deviation calculated second or deviations are calculated first and averaging is done second is mathematically irrelevant: the calculations would provide the same result. These calculations are shown mathematically in the Appendix.

As an example, assume a uniform target for cars of 30 mpg is legislated and the vehicle lifetime is deemed to be 150,000 miles. This implies a lifetime target fuel consumption of 5,000 gal/vehicle (150,000 miles/30 mpg). A manufacturer that sold 1 million cars with an average expected lifetime fuel consumption of 4,500 gal each (33.33 mpg), would acquire 500 credits per car, for each of 1 million cars, or 500 million credits. A manufacturer that sold 1 million cars with an average expected lifetime fuel consumption of 5,500 gal each (27.27 mpg) would face a 500 million gallon deficit and would need to purchase 500 million credits.

The government would assure that prices for tradable credits would not exceed some ceiling price by offering to sell credits to any manufacturer at some pre-determined offer price.

The government offer price per gallon could be set equal to the estimated external costs per gallon of gasoline use¹. If external costs (e.g., greenhouse gas emissions and international oil market) are estimated to be \$0.26/gal, the government would offer to sell credits at a price of \$0.26 per one-gallon credit.

The government offer price is important because it represents a “safety valve” preventing excessive costs to manufacturers (and consumers) in the event that unforeseen market changes or errors in setting targets make attaining the target more costly than originally projected². The market-clearing price of tradable credits would never exceed the government offer price because a buyer of credits could always turn to the government if the price of credits were above the government offer price.

The market price for credits would depend on whether the actual mean fuel economy³ of the entire new car fleet exceeded the target or fell short. If the mean economy fell short of the target, some manufacturers would be required to purchase credits from the government at the

¹ Applying this rule and using a reasonably accurate estimate of the lifetime miles of vehicles is economically efficient as long as the external cost per gallon of gasoline use during the future vehicle life has the same value for current decision making as the estimate of external costs used for the regulation.

² In addition, the "safety valve" limits the exercise of market power in the market for tradable fuel economy credits. Such market power could otherwise become an important problem if there were only a very small number of manufacturers that were selling tradable credits.

³ The phrase "mean fuel economy" as used here will always denote the harmonic mean of mpg. Calculating the harmonic mean of mpg is identical with calculating the arithmetic mean of gallons per mile.

government-determined price. Thus the market clearing price for credits would be equal to government-determined price. If, on the other hand, actual mean fuel economy of the entire new car fleet exceeded the target, the market price of the credits would be driven toward zero, although those firms that had excess credits would undoubtedly be able to sell them for some price above zero, but well less than the government-determined price. Finally, if actual mean fuel economy of the total new car fleet was just equal to the target, the market price of the credits would be above zero, but less than the government-determined price, with the actual price determined by the cost manufacturers face in increasing fuel economy. This is illustrated in Figure 1.

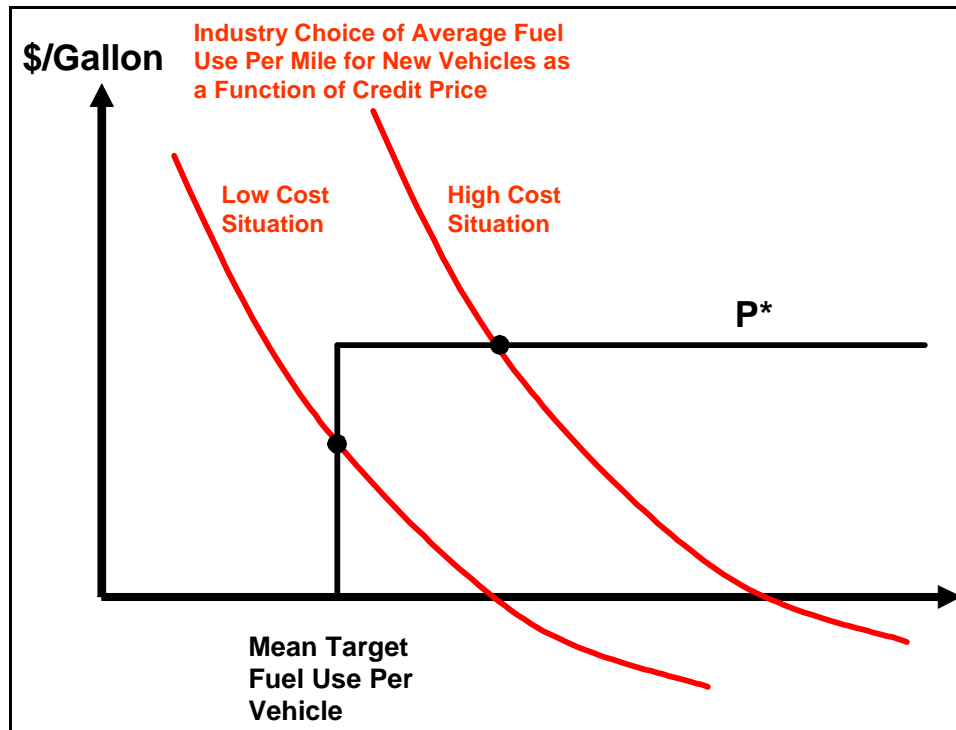


Figure 1
Tradable Credits: Two Possible Competitive Equilibria

In comparison to the current CAFE system, a tradable credits system would *increase* the range of options available to manufacturers. Currently manufacturers have two options: they can meet the standards or they can pay the government a civil penalty⁴. Under a system of tradable fuel economy credits, manufacturers would have more options: they could meet the targets, they could pay the government for credits, or they could purchase credits from other manufacturers. They would be free to choose.

⁴ The penalty is currently \$5.5 per 1/10 of a mpg by which the manufacturer misses the standard.

Similarly, in comparison to the current CAFE system, a tradable credits system would increase the range of attractive options available to manufacturers whose unconstrained fuel economy exceeded the target. Under CAFE, such manufacturers have no incentives to further increase fuel economy. But under a tradable fuel economy credits system, the same manufacturer would have the option of further increasing fuel economy and receiving additional credits that it could sell to other manufacturers. This would provide a manufacturer an incentive to increase fuel economy, one entirely absent under the current CAFE system.

For each manufacturer and each make and model of vehicle, the manufacturer's optimal choice satisfies the following condition: Marginal cost of reducing use of gasoline by one gallon equals the market clearing price of credits plus the "adjusted gasoline price". (See Figure 2.) The "adjusted gasoline price" is equal to the gasoline price multiplied by a factor equal to the discounted present value of the fraction of total miles driven in each future year. This definition of the "adjusted gasoline price" is developed in the mathematical appendix.

Suppose the marginal cost of reducing gasoline use enough to meet the target were greater than the sum of "adjusted gasoline price" plus the market price of credits: manufacturers could buy credits without being forced to install overly expensive technology, or to make changes to vehicle attributes that could damage sales. Conversely, if the marginal cost of reducing gasoline use to meet the fuel economy target were less than the sum of gasoline price plus market price of credits, the manufacturer would choose to make changes necessary to meet or to exceed the fuel economy target. Since the decisions would be made by and the resulting financial costs borne by the manufacturer, the manufacturer would have a motivation to correctly estimate costs of fuel economy increases. Under this system, the manufacturer could respond to automotive market conditions but would still have an enhanced incentive to increase fuel economy. Since all manufacturers could be expected to face the same price of gasoline and each would face the same price of credits, each manufacturer would operate so that the marginal cost of reducing gasoline use would be the approximately the same across all manufacturers.

The tradable credits system would have another advantage, especially if the sales price of tradable credits were made public⁵. Debates about environmental standards usually involve disputes about implementation cost: those favoring regulation contending that the standards will be cheap to implement, with manufacturers contending that the standards will be too expensive. But observations of sales prices of credits will indicate marginal costs of fuel economy improvements, since optimizing manufacturers can be expected to increase fuel economy to the point at which marginal cost of fuel savings equals the sum of gasoline price plus the market price of tradable credits.

It should be noted that a similar tradable credits scheme has been used for some time in the

⁵ Regulations could be established that required that sale prices of credits be made public. Absent such regulations, manufacturers might include confidentiality provisions in their agreements to buy or sell credits.

electrical power industry to reduce sulfur emissions. There is general agreement that tradable credits have been highly successful: they have reduced the economic cost of compliance, and they have reached the desired environmental goals. A similar tradable credits system has also been used in the RECLAIM program in Southern California for Nox emissions. The tradable fuel economy credits system would differ from tradable credits for sulfur emissions or the RECLAIM program in that the proposed system includes a "safety valve" where the other two emissions systems do not. The importance of the "safety valve" became apparent when the price of NOX permits jumped to above \$45,000 per ton in 2000, well above estimates of damages from NOX emissions, soon after the constraints first became binding. Fortunately this never became an issue for sulfur emissions credits.

A second reason for the "safety valve" is the possible exercise of market power in a market for fuel economy credits, given that relatively few automobile manufacturers can be expected to offer credits for sale. In contrast, the market for sulfur emissions involves a very large number of firms and there is a much smaller likelihood that there would be market power.

Tradable credits and attribute-based standards could be combined into a policy instrument that maintains the advantages of both. The targets in the tradable credits system would differ among automobiles, based on their weight, size, or other objective criteria. If such attribute based targets were adopted, a manufacturer would still be allowed to average across all its new vehicle sales. But each manufacturer would have a different mean fuel economy target, one that depended upon the fuel economy targets of the various makes and models of vehicles.

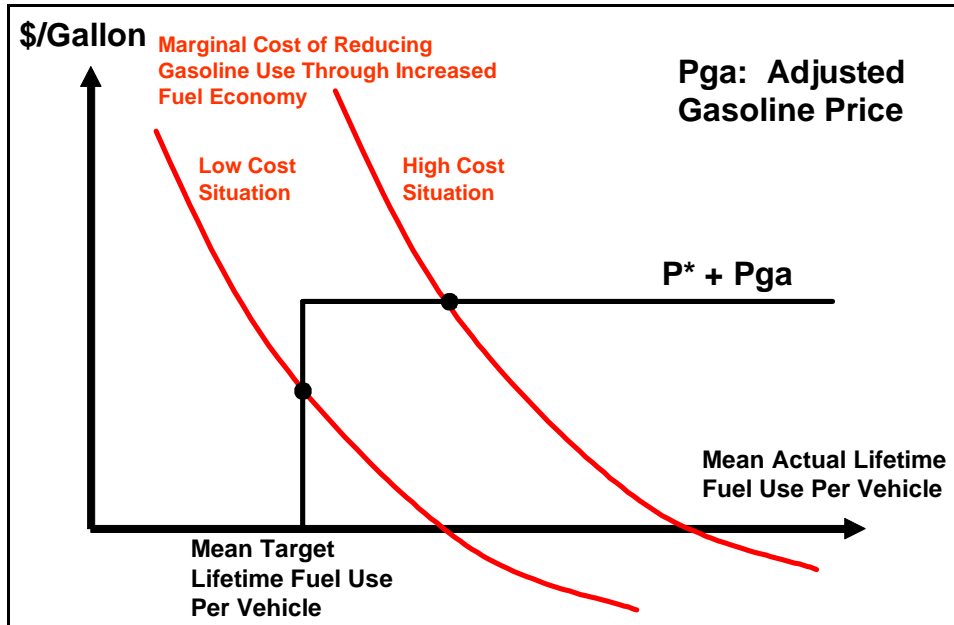


Figure 2
Determination of the Marginal Cost of Reducing Gasoline Use Through Increasing Fuel Economy. Analysis for Industry and for Each Manufacturer.

The economic efficiency properties of this system are very attractive. The equilibrium in competitive markets for fuel economy credits meets the necessary condition for minimizing the sum of producer cost plus consumer cost of gasoline use, when consumer cost of gasoline use takes into account actual consumer discounting. As discussed above, for each manufacturer and each make and model of vehicle, the manufacturer's optimal choice satisfies the following condition: Marginal cost of reducing use of gasoline by one gallon equals the market clearing price of credits plus the "adjusted gasoline price". This definition of the "adjusted gasoline price" is developed in the mathematical appendix. Therefore, if there is no systematic difference across vehicle makes and models about how consumers discount future gasoline costs, then in equilibrium the marginal cost of reducing use of gasoline by one gallon is the same across all vehicles from a given manufacturer, the domestic and import fleet from given manufacturer, and across manufacturers.

Equilibrium in competitive markets may meet the necessary condition for reducing fuel use by economically efficient amount. This will occur if the gasoline price equals the marginal cost of gasoline production and distribution and the market clearing price of credits is equal to the marginal external costs associated with changing fuel use through changes in fuel economy of vehicles. This second condition holds if P^* is set equal to the marginal external costs and the harmonic mean fuel economy targets are higher than the equilibrium harmonic mean fuel economy of actual sales. This implies that some manufacturers are purchasing credits from the government so that the equilibrium price of credits would be equal to P^* . The economic efficiency losses that occur if the price of credits is below P^* is illustrated in Figure 3..

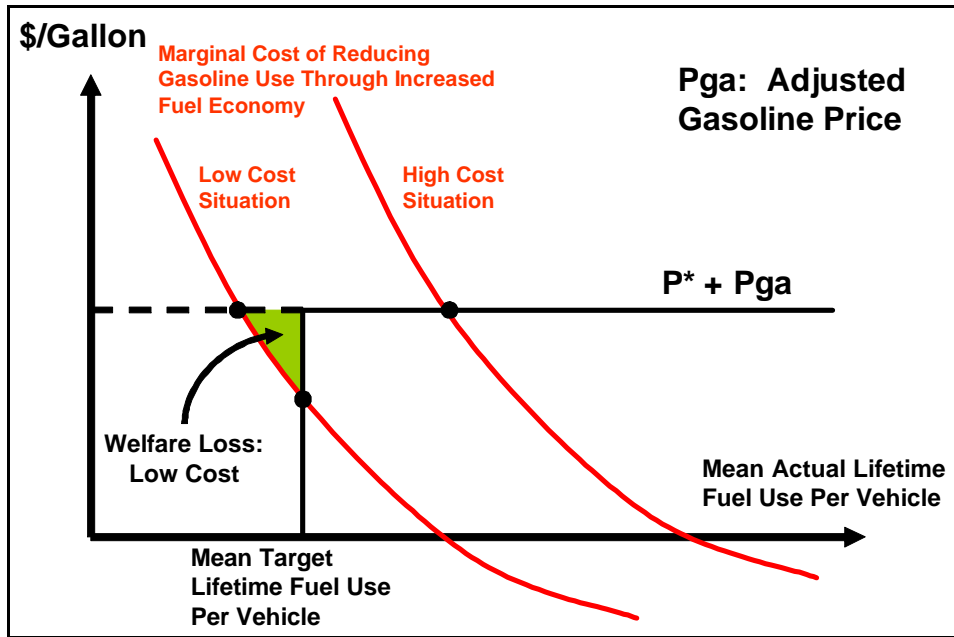


Figure 3
Welfare Losses Under a Tradable Credits System: Perfect
Competition in Credits Market

Under conditions of certainty, the current CAFE system does not have the same desirable economic efficiency properties. Since each manufacturer must meet the same harmonic mean fuel economy for its passenger cars and the same mean fuel economy for its light duty truck, there is no reason to expect that each would have the same marginal cost of reducing fuel use. In particular, those manufacturers who sell primarily large passenger cars or large light duty trucks would face a higher total cost and higher marginal cost of meeting the corporate average target than would manufacturers who sell primarily small passenger cars or small light duty trucks or a given increase in mean fuel economy, therefore, the current CAFE system fails to minimize the economic cost.

In addition, it is important to understand that policies must account for the real uncertainties in the system. In particular, the committee has identified a significant range of uncertainty about the costs of increasing fuel economy for the various types of vehicles. And there is significant uncertainty about the mix of vehicle types desired by consumers during the next ten to twenty years. Thus, even if the cost of fuel economy increases were known perfectly for the various vehicle types, the industry-wide costs would be uncertain when consumer choices were taken into account.

Under conditions of uncertainty, the tradable credits system has additional advantages over the current CAFE system. For the following analysis, the welfare costs of the current CAFE system

under certainty will be ignored. That is, it will be assumed that the total and marginal costs of reducing gasoline use through increasing fuel economy will be identical under the current CAFE and a tradable credits system. Thus the analysis examines additional advantages of the tradable credits system above and beyond the advantages discussed above for conditions of certainty.

Figure 4 shows the basic analysis. It is assumed that there could be either a high cost of reducing gasoline use through increased fuel cost or a low cost. At the time the regulations are set it is not known which will turn out to be the actual costs. The externalities are known and are equal to P^* , the government offer price under the tradable credits system.

It is assumed that the CAFE standards will be binding constraints under either the high or low cost situations. In that case, the CAFE level that minimizes expected cost would have a smaller target fuel use per vehicle than would be optimal if costs were known to be high and a larger target fuel use per vehicle than would be optimal if costs were known to be low. If costs turn out to be high, then the welfare loss per vehicle is the area of the triangle illustrated in Figure 4. This area is the integral of the difference between the marginal cost of reducing gasoline use through increased fuel economy and the sum of externalities plus adjusted gasoline price. Similarly, if costs turn out to be low, the welfare losses are represented by the other triangle in Figure 4. This triangle is the integral of the difference between the sum of externalities plus adjusted gasoline price and the marginal cost of reducing gasoline use through increased fuel economy.

Under a tradable credits system, the welfare losses occur only if the costs turn out to be low. In that case the market clearing price of the credits can be lower than P^* . However, because there are no welfare losses in the high cost situation and because reducing the target fuel use per vehicle can reduce the welfare losses in the low cost situation, the target fuel use per vehicle can be set lower than the CAFE standard would be set. That is, the mean target fuel economy under the tradable credits system should be larger than the mean target fuel economy under the current CAFE system. Losses in the low cost situation are represented by the small cross-hatched triangle in Figure 4, embedded within the loss triangle for the CAFE case.

As Figure 4 shows, the welfare losses under the tradable credits system are lower than the losses under the current CAFE system if costs turn out to be low and are non-existent if costs turn out to be high. Thus, in all cases, the welfare losses are smaller under the tradable credits system. The greater the uncertainty about marginal costs, the greater the advantage of the tradable credits system over the current CAFE system.

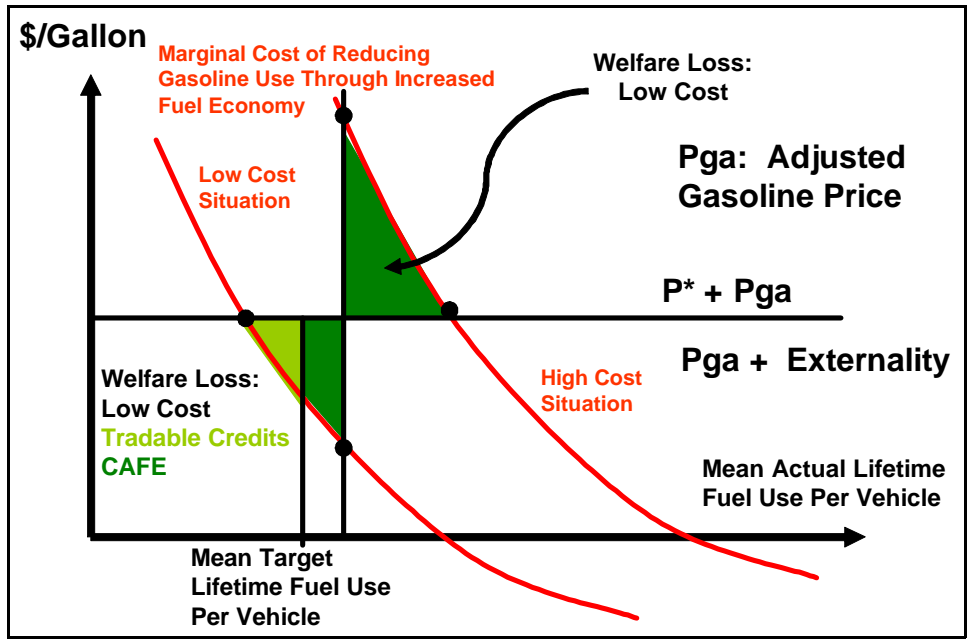


Figure 4
Efficiency Losses Under Uncertainty: Current CAFE System vs
Tradable Credits System.

Mathematical Appendix

Tradable Credits Mechanics: Uniform target across all vehicles.

Set target fleetwide fuel economy: mpg*

(example, 30 miles per gallon)

Set deemed lifetime vehicle miles traveled: VM

(example, 150,000 miles)

Lifetime fuel use target per vehicle: F*

$$F^* = VM / \text{mpg}^*$$

(example, 150,000/ 30 = 5000 gallons)

Actual harmonic mean fuel economy: mpg

(example, 25 miles per gallon)

Projected lifetime fuel use per vehicle: F

$$F = VM / \text{mpg}$$

(example, 150,000/25 = 6000 gallons)

Credit per vehicle (if positive) or Deficit per vehicle (if negative): C

$$C = F^* - F$$

$$C = VM (1/\text{mpg}^* - 1/\text{mpg})$$

(example, 5000 gallons - 6000 gallons = - 1000 gallons per vehicle, a deficit)

Total credits (or deficits) for a manufacturer: TC

Number of vehicles sold by a manufacturer: N

TC equals credit (or deficit) per vehicle multiplied by the number of vehicles sold

$$TC = N C = N (F^* - F)$$

(example, 1000 vehicles, deficit = 1,000,000 gallons)

Tradable Credits Mechanics: varying targets across various vehicle classes (for example, targets which vary with the vehicle weight).

Assume that there are K classes of vehicles. These could be weight classes, size classes, or classes based on vehicle characteristics (e.g., trucks vs passenger cars).

Assume sales of N(i) vehicles in class i.

Define a class-specific target fuel economy for each class: mpg(i)*

Total lifetime target fuel use, total for all vehicles: TF*

$$TF^* = \sum N(i) / \text{mpg}(i)^*$$

Written in another form

$$TF^* = N \sum [N(i) / N] / \text{mpg}(i)^*$$

The summation is then the sale-volume-weighted harmonic mean of target miles per gallon of the various vehicle classes, or equivalently. The summation is the sale-volume-weighted, average of target gallons per mile of the various vehicle classes

Projected total lifetime actual fuel use, total for all vehicles: TF

$$TF = \sum N(i) / \text{mpg}(i)$$

Written in another form

$$TF = N \sum [N(i) / N] / \text{mpg}(i)$$

The summation is then the sale-volume-weighted harmonic mean of actual miles per gallon of the various vehicle classes, or equivalently, the summation is the sale-volume-weighted, average of actual gallons permile of the various vehicle classes.

Total credits (or deficits) for a manufacturer: TC

$$TC = TF^* - TF$$

Operation of the market for credits: mechanics

Manufacturers having more credits than needed can sell them

Manufacturers needing more credits can buy them

Government offers to sell credits at a fixed price, P*

P^* should be set equal to external cost for using one gallon of gasoline
Market price of credits: P

Analysis of Tradable Credits Market

Market price of credits would never be greater than P^* but could be smaller
Analysis is shown in Figure 1, in the body of the paper.

If overall fleet average fuel use per vehicle exceeds fuel economy standard
(harmonic mean of fuel economies smaller than harmonic mean of targets)

There will be an excess supply of credits

Competitive equilibrium market price will be pushed to zero after all
information is available (after all production is completed)

Market power of sellers implies that prices will exceed zero

If overall fleet fuel average fuel use per vehicle is smaller than fuel economy
standard (harmonic mean of fuel economies greater than harmonic mean of targets)

Some firms would need to buy from the government

Market clearing price would be P^*

If overall fleet is equal to the average target

Competitive equilibrium price could be anywhere between 0 and P^* and
would be whatever is needed to bring fleet to just the average target.

I believe that market power of sellers implies that prices will probably equal or
approach P^*

Financial transfers from buying and selling credits

If manufacturer exactly meets mpg* target, then there are no financial transfers

If manufacturer fails to meet mpg*, then it will buy credits, transferring money to a
manufacturer whose efficiency exceeds the standard or to the government

If manufacturer exceeds mpg* target, it will be benefit financially.

Economic Efficiency of Tradeable Credits: No uncertainty

Equilibrium in competitive market meets conditions for minimizing the sum of producer
cost plus consumer cost of gasoline use, when consumer cost of gasoline use takes into
account actual consumer discounting.

Marginal cost of reducing use of gasoline by one gallon is the same across:
 All cars from given manufacturer
 Domestic and Import Fleet from given manufacturer
 All Manufacturers

Optimal choice for each manufacturer: Marginal cost of reducing use of gasoline by one gallon equals the market clearing price of credits plus the “adjusted gasoline price”. See Figure 2, in the body of the paper.

If “adjusted gasoline price” is the same for all manufacturers then, since price of credits is the same across all manufacturers, marginal cost of reducing use of gasoline by one gallon must be the same for all manufacturers and all vehicles.

“Adjusted gasoline price” is gasoline price adjusted by future discounting. The adjustment is calculated in the following.

Let OG be the change in gallons per mile from technology change

Let f_t be the discount factor from time of fuel use to time of vehicle sale

Let M_t be the miles driven in year t after vehicle sale

Assume price of gasoline is constant over time and equal to P_g

Let M be the total lifetime miles

M may or may not be equal to VM; VM is a policy variable; M is the actual mileage

$$M = \sum M_t \text{ where summation is over time}$$

Discounted present value of future gasoline cost savings: VS

$$VS = P_g \text{ OG } \sum M_t f_t$$

Change in gasoline used over vehicle lifetime = $\text{OG } \sum M_t$

The adjusted gasoline price is then the change in consumer value (VS) per change in gallons of gasoline used over vehicle lifetime:

$$\frac{\{P_g \text{ OG } \sum M_t f_t\}}{\{\text{OG } \sum M_t\}} = P_g \frac{\{\sum M_t f_t\}}{\sum M_t} = P_g \sum \left[\frac{M_t}{M} \right] f_t$$

Thus the “adjusted gasoline price” is equal to the gasoline price multiplied by a factor equal to the discounted present value of the fraction of total miles driven in each future year.

If consumers make decisions based on the discounted present value of gasoline costs, using parameters from our study (15600 miles the first year,

declining 4.5% per year, over 14 years total, with 12% discount rate) then:

$$\nabla [M_t / M] f_t = 57\%$$

If consumers make decisions based on the undiscounted value of gasoline costs over the first three years of vehicle life, using parameters from our study, then

$$\nabla [M_t / M] f_t = 27\%$$

Marginal cost of reducing use of gasoline by one gallon equals the market clearing price of credits plus the “adjusted gasoline price”

Gasoline price must be adjusted based on how consumers discount future gasoline expenditures.

Credits are based on non-discounted use of gasoline over entire life of vehicle; they look like a direct change in manufacturing costs.

Equilibrium in competitive market may meet condition for reducing fuel use by economically efficient amount. This will occur if:

Gasoline price equals the marginal cost of gasoline production and distribution;
Market clearing price of credits is equal to the marginal external costs associated with changing fuel use through changes in fuel economy of vehicles.

This second condition holds if P^* is set equal to the marginal external costs and the harmonic mean fuel economy targets are higher than the equilibrium harmonic mean fuel economy of actual sales. This implies that some manufacturers are purchasing credits from the government so that the equilibrium price of credits is equal to P^* .

All manufacturers reduce fuel use from free market levels

High cost manufacturer (large vehicles) make cars with fuel use greater than those of medium cost manufacturer and those use more fuel than those made by a low cost manufacturer (small vehicles).

Economic Losses with Tradable Credits Under Uncertainty.

Losses will occur if the target average fuel use per vehicle is greater than the market equilibrium average fuel use per vehicle. This can occur if there is uncertainty about industry-wide marginal cost curves or if the targets fuel use per vehicle is set higher than the expected market outcome.

Losses occur only when the equilibrium new fleet average fuel use for $P = P^*$ is

lower than the target fuel use averaged over all vehicles. This can occur under uncertainty, if costs of reducing fuel use turn out to be enough lower than expected.

Loss is the integral of “adjusted gasoline price” plus marginal externality minus marginal cost of reducing fuel use.

This is shown in Figure 3 in the body of the paper.

Expected losses can be reduced by reducing average target fuel use (increasing harmonic mean of target fuel economy)

But increasing harmonic mean of target fuel economy increases the transfer payments from the automobile industry to the government.

The welfare losses under uncertainty can be compared with the welfare losses under uncertainty for the current CAFE system.

Under the current CAFE system the CAFE harmonic mean fuel economy target

Incentives to modify sales of various vehicle classes, in particular, large vs small vehicles

Whether there were any incentives to change the numbers of vehicles sold under the various vehicle classes will depend on how the target changes across vehicle classes. Even the direction of change motivated by the system would depend on how the target changes across vehicle classes.

Assume manufacturer started at optimal mix of vehicles sold before the credit system

Assume manufacturer considering whether to sell one more vehicle from class j and sell one less from class i, where $\text{mpg}(j) > \text{mpg}(i)$. This assumes that the projected market determined fuel economies differ between the classes, with class j having a higher fuel economy than class i.

Change in net number of credits is:

$$\begin{aligned} \text{OC} &= \text{VM} \{ 1 / \text{mpg}(i) - 1 / \text{mpg}(i)^* \} - \text{VM} \{ 1 / \text{mpg}(j) - 1 / \text{mpg}(j)^* \} \\ &= \text{VM} \{ 1 / \text{mpg}(i) - 1 / \text{mpg}(j) \} - \text{VM} \{ 1 / \text{mpg}(i)^* - 1 / \text{mpg}(j)^* \}. \end{aligned}$$

Case 1: No class-based distinctions in targets.

Large cars, small cars, large SUVs, small SUVs, etc. have same target.

This corresponds to the current situation for CAFE, but with an elimination of the

distinction between trucks and passenger cars.

Under these assumptions:

$$OC = V \{ 1 / \text{mpg}(i) - 1 / \text{mpg}(j) \} > 0$$

Thus the manufacturer would increase its sales of credits or would be able to reduce its purchases of credits if it sold one more automobile from the class that had greater fuel economy.

Such a system would provide an incentive to shift the mix of vehicles sold toward classes that had higher miles-per-gallon. This is typically the smaller vehicles. Thus this system provides an incentive toward selling more small vehicles and fewer larger vehicles.

Case 2: Class-based distinctions in targets could eliminate shifts in mix of vehicles.

Under these assumptions:

$$OC = V \{ 1 / \text{mpg}(i) - 1 / \text{mpg}(j) \} - V \{ 1 / \text{mpg}(i)^* - 1 / \text{mpg}(j)^* \}$$

$$\text{Set } \{ 1 / \text{mpg}(i)^* - 1 / \text{mpg}(j)^* \} = \{ 1 / \text{mpg}(i) - 1 / \text{mpg}(j) \}$$

That is, the target change in fuel consumption per mile from shifting between classes is set equal to the projected actual change in fuel consumption per mile from such a shift between classes.

Then the change in OC would be zero. The manufacturer would neither gain nor lose money (through the purchase and sales of credits) by a decision to sell more of the high mpg class and the same amount less of the low mpg class.

There would be no incentive through this system, for the manufacturer to shift the mix of cars sold from the various classes.

Additional Analysis of Fuel Efficiency Credits Market

Observation of P gives important information for governmental decision making

If P turns out to be small, then the cost for each manufacturer to increase fuel economy is low

If P reaches its limit of P^* and the government is selling credits, then the cost for each manufacturer to increase fuel economy can be measured by the sum of P^* and the adjusted gasoline price.

If P reaches its limit of P^* and the government is not selling credits, then the cost for each manufacturer to increase fuel economy has an upper limit of the sum of P^* and the adjusted gasoline price. For the buyers of credits, this sum should be the marginal cost of reducing gasoline use by increasing fuel economy. For the sellers of credits, the sum may be greater than the cost to increase fuel economy, since this price may reflect the exercise of market power.

The information embedded in P can be useful for regulatory decision making

Adjustment processes:

Information is useful only if there is ex post policy adjustment.

Congress could enact a periodic adjustment mechanism that will take place after information becomes available.

Incentives to mis-estimate cost may be reduced

There will no longer be incentives on manufacturers to show that fuel efficiency increases are expensive

There will no longer be incentives on environmental or other public interest groups to show that fuel efficiency increases are inexpensive