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A Natural Experiment in the Hybrid Vehicle Market

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Abstract

This study measures the economic incidence of the hybrid vehicle tax credit implemented in the Energy Policy Act of 2005. By comparing hybrids to gasoline-powered counterparts as the credit is phased out and expires, we are able to isolate the impact of the credit on the market price of hybrid vehicles. We conclude that hybrid prices increase by $0.75 on average for every additional dollar of credit. Thus, the majority of the subsidy accrues to manufacturers, potentially encouraging producers to increase the variety and availability of hybrid models on the market.

JEL Classification Codes: H22, L62, Q48, Q53

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Introduction and Background

The Energy Policy Act of 2005 instituted a tax credit for individuals who purchased a hybrid vehicle after December 31, 2005. Hybrid vehicles are powered by a combination of an internal combustion engine and electric motors and can achieve fuel efficiency well in excess of typical cars with a stand-alone gasoline engine. For example, in 2008 the five most fuel efficient vehicles sold in the United States were all fitted with a hybrid drive train.

Manufacturers wishing to have a vehicle eligible for the tax credit must have it certified by the Internal Revenue Service, and the amount of the tax credit varies by model and year of the vehicle depending largely upon the fuel efficiency gains produced by the hybrid vehicle in comparison to similar non-hybrid models. The maximum allowable credit is $3,400, and in practice the IRS has certified actual tax credit amounts between $250 and $3,150 with an average of about $2,000 per vehicle.

The tax credit phases out once a particular manufacturer has sold 60,000 hybrid vehicles of any year or model. In the quarter the manufacturer sells its 60,000th hybrid car or truck and the quarter immediately after this, the credit is unchanged. In the subsequent two quarters, the credit is set at 50% of its previous level, and in the next two quarters the credit is lowered again to 25% of its original level. The tax credit is eliminated completely in the 6th quarter after the manufacturer hits the 60,000 vehicle threshold. Toyota reached 60,000 in hybrid sales during the 2nd quarter of 2006, and thus its tax credit began to phase out on October 1, 2006. Honda's tax credit began to phase out on January 1, 2008. Other manufacturers, including Ford, General Motors, and Nissan, had not reached 60,000 in total sales by the third quarter of 2008.

The statutory incidence of this subsidy is granted to the purchaser of car or truck who is given a tax credit for the designated amount that may be deducted from their annual individual income tax. It should be noted that the buyer may not be eligible for the full tax credit if their total tax liability for the year in question is lower than the amount of the credit (which is presumably a rare occurrence for purchasers of new cars) or if the buyer is subject to the Alternative Minimum Tax (AMT).

The economic incidence of the subsidy, however, may fall on either the manufacturer or the buyer, regardless of the statutory incidence of the tax credit. Standard economic analysis states that the economic incidence of a tax (or in this case, a subsidy) is independent of the statutory incidence and depends on the relative elasticities of the supply and demand of the good. In a market with a low price elasticity of demand compared to the price elasticity of supply, the benefits of a subsidy will accrue primarily to suppliers while in a market where the price elasticity of demand is higher than the price elasticity of supply, consumers will receive the majority of the benefits of a subsidy.

The relatively large size of the hybrid tax credit along with the discrete nature of the phase out provides an opportunity to clearly examine the economic incidence of this subsidy. Several researchers have previously addressed the effectiveness of the Energy Policy Act of 2005 in promoting hybrid adoption. Kahn (2008) notes that hybrid adoption is largely a function of social preferences and suggests that early adoption, at least, of the technology was primarily due to non-economic reasons, an idea echoed by Gallagher and Muehlegger (2008). Gallagher and Muehlegger also note that the effect of income tax credits, which the consumer receives at a

point in the future, have significantly less impact on sales than credits received at the time of purchase.

Beresteanu and Li (2008) utilize a panel of vehicle sales in 22 metropolitan statistical areas to estimate that the average hybrid vehicle subsidy of $2,432 in 2006 as a result of the tax credits described previously resulted in a 27% to 32% increase in hybrid vehicle sales in that year. Sallee (2007) examines microlevel sales data on the Toyota Prius, the most popular hybrid model, and claims that consumers capture $0.975 of every dollar of federal tax credit implying that the price elasticity of demand must extremely low in comparison to the price elasticity of supply. Combined with Beresteanu and Li's assertion that the tax credit resulted in a significant increase in hybrid sales, the only possible to reconcile these two findings is if supply is highly elastic while demand is generally inelastic. The finding that demand is inelastic for hybrids, especially for the distinctly styled Toyota Prius, is corroborated by Beresteanu and Li (2008) as well as Kahn (2008). However, there is little reason to believe that supply for hybrids is particularly elastic. Indeed, one of the most common complaints about hybrid vehicles is that they can be very difficult to find in stock at dealerships. Gallagher and Muehlegger (2008) specifically note that production constraints have limited sales of the Prius and Honda Civic hybrid several times.

This analysis investigates the economic incidence of hybrid tax credits and, unlike previous research, finds that for every dollar of tax credit provided by the Energy Policy Act, the price of hybrid vehicles rose by approximately $0.75 suggesting that manufacturers, not consumers, were the primary beneficiaries of this subsidy.

Data and Model

This paper utilizes "True Market Value" (TMV) vehicle pricing price data from Edmunds.com, a major automotive information website. According to Edmunds.com, the TMV monthly estimates are calculated based on the vehicle's invoice price, manufacturer's suggested retail price, supply and demand for the vehicle in that month, data on actual vehicle transactions, current manufacturer-to-dealer incentives and relative brand strength (http://www.edmunds.com/popupinfo/calculatetmvprices.html).

The data consist of monthly nationwide average market prices for all hybrid vehicle model years that were both eligible for the tax credit but also subject to the phase out of the subsidy. Specifically, these data include pricing information for the Toyota Prius (2005-2007), Toyota Highlander (2006-2007), Toyota Camry (2007), Lexus RX (2006-2007), and the Honda Civic (2008). Data for both two-wheel drive and all-wheel drive versions were included for the Highlander and Lexus RX bringing the total number of model years examined to 13. Price data for identical model year non-hybrid vehicles were also collected. With the exception of the Toyota Prius, all other hybrid vehicles sold by these companies during the time period in question were available in a non-hybrid version. In addition to the Edmunds TMV, sale month and model year, we incorporate monthly gasoline price data obtained from the U.S. Bureau of Labor Statistics' Average Price Data (U.S. city average per gallon, all gasoline types).

We utilize a difference-in-differences regression framework to isolate the impact of the credits on the price of hybrid vehicles. This strategy compares the prices of hybrids and non-hybrids, before, during and after the credit phase out. If any of the hybrid subsidy is received by the seller (i.e. as long as demand is not perfectly inelastic), the credit phase out should result in a

decrease in the market price of hybrids relative to non-hybrids.

A true difference-in-differences model assumes a treatment and a control group, with only one group (the treatment group) affected by the policy change in question. In this case, while only hybrids are directly impacted by the credits (and their corresponding phase-out), it is possible that the credits will have an indirect impact on non-hybrid prices. Since hybrids and non-hybrids are potentially substitute goods, a change in the price of hybrids may also impact the price of their regular gasoline counterparts. As a result, the credits and their phase out may cause movement in all vehicle prices in our sample and may not simply affect hybrid prices as would be the case in a standard difference-in-difference model.

We estimate the following equation by OLS:

$$(1)\quad TMV_{jt} = \alpha_1 hybrid_{jt} + \alpha_2 credit_{jt} * hybrid_{jt} + \alpha_3 credit_{jt} * nonhybrid_{jt} + \alpha_4 gas_t * hybrid_{jt} + \alpha_5 gas_t * nonhybrid_{jt} + \theta_j + \tau_t + h_{jt} + n_{jt} + \varepsilon_{jt}.$$

TMV is the Edmunds.com True Market Value for model *j* in month *t*. The *hybrid* variable is an indicator equal to 1 if the vehicle is a hybrid and zero otherwise, *nonhybrid* is equal to 1 if the vehicle has a regular gas-powered engine, *credit* is the value of the hybrid vehicle tax credit for model *j* in month *t*, and *gas* is the average gasoline price in the current month. The equation also includes fixed effects for the thirteen vehicle models (θ_j), monthly dummies (τ_t), and hybrid and non-hybrid time trends (h_{jt}, n_{jt}) capturing the number of months since each model came on the market. Finally, ε_{jt} is a random error term.

The variable of interest in this equation is α_2, the coefficient on the interaction between *credit* and *hybrid*. The coefficient α_3 captures the change in the market equilibrium price for non-hybrids in response to the fact that the credit reduces the hybrid price paid by consumers.

Therefore, α_2 represents the additional impact of the credit on hybrids, i.e. the incidence of the subsidy, provided that no unobservable factors cause further simultaneous movement in the relative prices of hybrids and non-hybrids. The results from estimating equation (1) are reported in Table 2.

As expected, the results show that the market price of hybrids rises as a result of the tax credit. For every additional dollar of credit the average hybrid price increases by $0.75, indicating that three-quarters of the subsidy is actually collected by producers. This implies that the true subsidy amount received by consumers ranges from $63 to $788. The sign of the coefficient on the *credit*nonhybrid* interaction term is negative but not different from zero at a 10% level of significance. While care should be taken when interpreting coefficients that are not statistically significant, this result indicates that an extra dollar of credit for hybrid vehicles results in a $0.46 decrease in the price of non-hybrids. This implies that hybrids and non-hybrids are indeed substitutes, i.e. demand for non-hybrids falls since the subsidy reduces (by $0.25 for every dollar of credit) the price consumers pay for hybrids.

Conclusions and Policy Recommendations

The results presented in this paper, unlike those in previous research, suggest that the economic incidence of the hybrid vehicle tax credit has been received primarily by manufacturers rather than consumers. This result, however, should not be interpreted as an indication that the tax credit has been ineffective at promoting the adoption of hybrid vehicles. If manufacturers capture 75% of the subsidy, as suggested in this paper, then given an average tax credit of roughly $2,000 per vehicle for the first 60,000 hybrids sold, the hybrid vehicle tax

credit amounts to at least a $90 million subsidy to each manufacturer as an enticement for automobile companies to develop hybrid cars and light trucks. Combined with evidence from Kahn's (2008) finding that social preferences and not economic reasons are the primary motivators of early adoption of hybrid technology, a subsidy like the hybrid tax credit that provides substantial incentives for manufacturers to provide hybrid models in the first place may be more valuable than subsidies that would simply lower the price of the such vehicles for consumers once the models are made available.

Table 1. Hybrid Vehicle Credit Scheme

Toyota*	Camry Hybrid	**Purchase Date**	
		1/1/06 -- 9/30/06	$2,600
		10/1/06 --3/31/07	$1,300
		4/1/07 -- 9/30/07	$ 650
		10/1/2007 and later	$ 0
Toyota*	Prius	**Purchase Date**	
		1/1/06 -- 9/30/06	$3,150
		10/1/06 --3/31/07	$1,575
		4/1/07 -- 9/30/07	$787.50
		10/1/2007 and later	$ 0
Toyota*	Highlander Hybrid 2WD and 4WD	**Purchase Date**	
		1/1/06 -- 9/30/06	$2,600
		10/1/06 --3/31/07	$1,300
		4/1/07 -- 9/30/07	$ 650
		10/1/2007 and later	$ 0
Lexus*	RX 400h 2WD and 4WD	**Purchase Date**	
		1/1/06 -- 9/30/06	$2,200
		10/1/06 --3/31/07	$1,100
		4/1/07 -- 9/30/07	$ 550
		10/1/2007 and later	$ 0
Honda**	Civic CVT	**Purchase Date**	
		Prior to 1/1/08	$2,100
		1/1/08 -- 6/30/08	$1,050
		7/1/08 -- 12/31/08	$525
		1/1/09 and later	$0

Data from http://www.irs.gov

Table 2. Impact of Hybrid Tax Credits on Vehicle Prices

	Vehicle Price
Hybrid	7,490.175**
	(1,129.917)
Credit*hybrid	**0.752***
	(0.352)
Credit*nonhybrid	-0.464
	(0.363)
Prius 2005	13,400.569**
	(1,806.327)
Prius 2006	16,326.997**
	(1,272.178)
Prius 2007	16,516.954**
	(1,000.199)
Highlander 2006 awd	26,146.816**
	(1,393.123)
Highlander 2006 fwd	24,688.195**
	(1,384.284)
Highlander 2007 awd	27,066.043**
	(958.791)
Highlander 2007 fwd	25,617.081**
	(958.300)
Camry 2007	20,759.215**
	(1,076.355)
Lexus rx 2006 awd	37,476.883**
	(1,335.895)
Lexus rx 2006 fwd	35,895.827**
	(1,243.801)
Lexus rx 2007 awd	36,199.402**
	(977.660)
Lexus rx 2007 fwd	35,151.256**
	(998.157)
Civic 2008	17,044.729**
	(1,129.354)
Gas*non-hybrid	1,130.550**
	(408.379)
Gas*hybrid	-663.288
	(446.683)
Non-hybrid trend	-188.982**
	(57.173)
Hybrid trend	-7.983
	(57.405)
Observations	369

Robust standard errors in parentheses. Results from estimating equation (1) by OLS. Regression also includes sale month dummies. *Vehicle Price* is Edmunds.com TMV. Prices in Jan 2007 dollars. *Hybrid*=1 for hybrid vehicles and 0 otherwise. *Credit*=tax credit amount for vehicle model in current month. *Gas*=average U.S. gasoline price in current month. + significant at 10%; * significant at 5%; ** significant at 1%

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