Did Federal Incentives Boost Sales of Hybrid Electric Vehicles?

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Abstract

Transportation represents a significant contribution to anthropogenic greenhouse gas emissions. The promotion of adoption of new, more efficient vehicle technologies through incentives can help as a climate change mitigation strategy. This study assesses the overall effectiveness of several of these incentives using econometric methods. Our primary model employs a novel lagged dependent variable of sales to represent natural growth from technological diffusion using a generalized method of moments estimator with both fixed effects and first differences. Our primary results indicate that when natural growth is accounted for, the Tax Relief Act of 2004 is not statistically significant but the Energy Policy Act of 2005 resulted in significant increases in sales for hybrids ranging from 3% to 20% depending on the vehicle model.

Background and Data

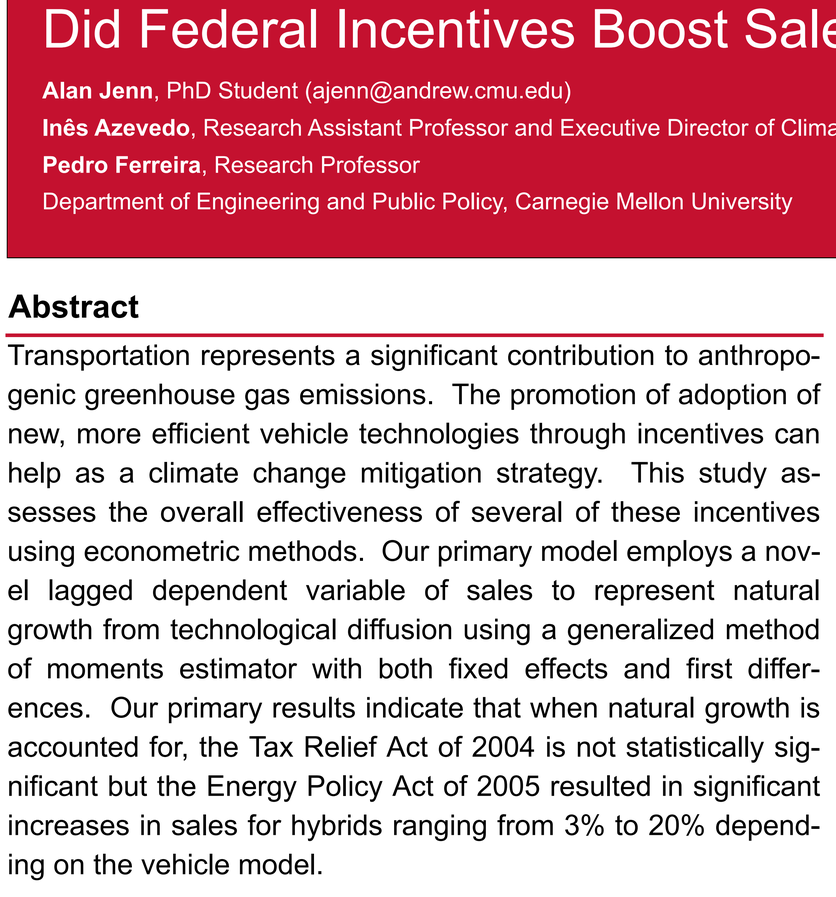

Figure 1: Total Monthly Sales of Vehicles in the US and the Total Monthly Sales of Hybrid Vehicles in the US. Data collected from Autonews Data Archives and Hybridcars Dashboard.

Methodology

Our unique approach to the regression involved the inclusion of a lagged dependent variable to simulate an S-shaped adoption curve. The structural form of the regression was constructed from the simplest specification, adding controls until the following form was obtained:

$$S_{i,t} = \alpha + \pi(S_{i,t-1}) + \beta(Policy_{i,t}) + \gamma(x_{i,t}) + \delta(x_{i,t} \cdot HybridDummy) + u_{i,t} + \varepsilon_{i,t}$$

- i is an indicator for vehicle model
- t is an indicator for time period (month)
- S represents monthly sales
- *Policy* represents incentive variables of interest
- x represent control variables
- *HybridDummy* is a dummy variable for whether i is an HEV

Incentive variables are the Tax Relief Act of 2004 and the Energy Policy Act of 2005. Control variables include Cash for Clunkers, production stoppage, unemployment, disposable income, interest rates, and gas prices.

Our regression models are estimated using generalized method of moments with fixed effects and first differences estimators. The GMM is employed to address bias issues with the use of the lagged dependent variable and the FE/FD approach helps to account for omitted variable bias.

Results

Table 1: Generalized Method of Moments, Fixed Effect Regression Results

VARIABLES	Coefficients (Robust Standard Errors)					
L.ln(sales)	0.914***	0.911***	0.910***	0.911***	0.914***	0.910***
	(0.00832)	(0.00845)	(0.00851)	(0.00845)	(0.00837)	(0.00852)
L.ln(sales)*hybrids	-0.0335	-0.0250	-0.0410	-0.0253	-0.0392	-0.0353
	(0.0273)	(0.0286)	(0.0278)	(0.0283)	(0.0278)	(0.0287)
TaxReliefAct	**-0.0678**	**-0.0373**	**-0.0417**	**-0.0432**	**-0.0589**	**-0.0258**
	(0.0802)	**(0.0835)**	**(0.0805)**	**(0.0818)**	**(0.0806)**	**(0.0837)**
TaxReliefAct*nonhybrids	**-0.0354*** **	**-0.0393*** **	**0.0280**	**-0.0382*** **	**-0.0431*** **	**-0.0409*** **
	(0.0101)	**(0.0102)**	**(0.0173)**	**(0.0101)**	**(0.0112)**	**(0.0112)**
EnergyPolicyAct	**4.80e-05** **	**6.95e-05*** **	**4.10e-05** **	**6.83e-05*** **	**3.66e-05** **	**5.57e-05** **
	(1.91e-05)	**(2.69e-05)**	**(1.93e-05)**	**(2.56e-05)**	**(1.84e-05)**	**(2.70e-05)**
EnergyPolicyAct*nonhybrids	**-0.0840*** **	**-0.0796*** **	**0.0547***	**-0.0824*** **	**-0.104*** **	**-0.0831*** **
	(0.0115)	**(0.0114)**	**(0.0306)**	**(0.0114)**	**(0.0176)**	**(0.0177)**
CashForClunkers	0.0350	0.0667**	0.0340	0.0641**	0.0558*	0.0757***
	(0.0261)	(0.0274)	(0.0261)	(0.0272)	(0.0287)	(0.0293)
ProductionStoppage	-0.660***	-0.668***	-0.669***	-0.668***	-0.661***	-0.675***
	(0.0578)	(0.0582)	(0.0585)	(0.0583)	(0.0582)	(0.0586)
PriusAdvertise	0.257	0.263	0.185	0.264	0.242	0.252
	(0.167)	(0.168)	(0.166)	(0.168)	(0.164)	(0.164)
Ln(Unemployment)		-0.0999***				-0.101***
		(0.0206)				(0.0212)
Ln(Unemployment)*hybrids		0.196**				0.198**
		(0.0941)				(0.0925)
Ln(Income)			-0.668***			
			(0.138)			
Ln(Income)*hybrid			1.170***			
			(0.284)			
Ln(Interest)				0.0200***		
				(0.00415)		
Ln(Interest)*hybrid				-0.0394**		
				(0.0186)		
$Ln(GasPrice)_{t-6}$					0.0868	0.00574
					(0.0671)	(0.0691)
$Ln(GasPrice)_{t-6}$*hybrid					0.505**	0.606***
					(0.201)	(0.198)
Observations	19,962	19,962	19,962	19,962	19,962	19,962
R^2	0.912	0.913	0.913	0.912	0.912	0.913
# of Groups	326	326	326	326	326	326
Hansen J Stat	0.00333	0.00379	0.00489	0.00394	0.00546	0.00566

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Results Continued

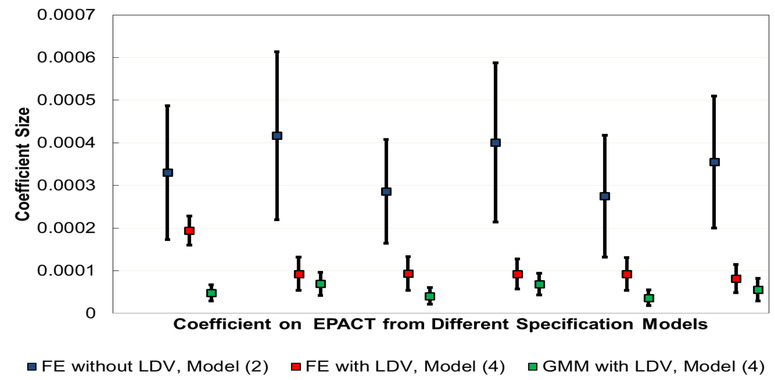

Figure 2: Demonstrating overestimation bias in coefficients when not accounting for natural growth of technology

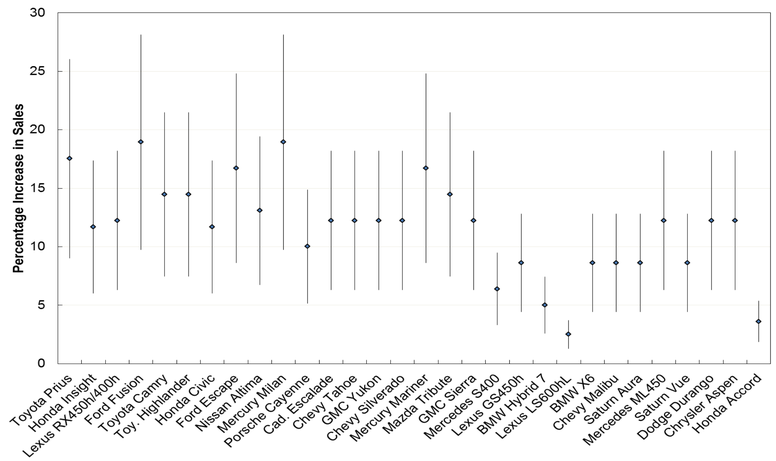

Figure 3: Percentage increase in sales of hybrid vehicles by model, attributable to the Energy Policy Act of 2005

Conclusions

We found that our general methodology is an important contribution to the body of existing work, especially to incorporate natural growth characteristics. The Energy Policy Act of 2005 was found to be statistically significant in increasing sales of hybrid electric vehicles. As a climate mitigation strategy, a future study can be conducted to measure the effectiveness of these policies by estimating the savings in greenhouse gas emissions. In addition, our regression models suggest that raising gas prices could potentially be an alternative strategy that would have the dual effect of decreasing emissions and generating substantial revenue, independent of other effects.

Acknowledgements

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