

California Clean Air Stickers: A \$350 Million Missed Opportunity?

Sharon Shewmake¹

Draft #2

ABSTRACT

From 2005 to early 2007, California issued 85,000 Clean Air stickers that allowed three models of hybrid cars to drive on High Occupancy Vehicle (HOV or ‘carpool’) lanes with a single occupant. These stickers could not be transferred between cars, but could be transferred between people by the sale of a car with a sticker on it. Through a hedonic model of car prices, we can estimate the willingness-to-pay for a Clean Air sticker and how it has changed over time. Since the program is set to be discontinued January 1, 2011 when the sticker will become useless, the price of the stickers should evolve over time. In March 2007, the willingness-to-pay for one of these stickers was approximately \$5,800; as of May 2009 it is \$1,400. This provides insight into how much drivers are willing to pay for congestion relief as well as information on consumers’ value for alternative fuel vehicles. The results suggest that policies allowing hybrid or clean cars to utilize HOV lanes with a single occupant may not be economically justified once opportunity costs are taken into account.

INTRODUCTION

High Occupancy Vehicle² (HOV) lanes were intended to decrease congestion by providing special lanes for vehicles carrying two or more people. By providing travel time savings and greater travel time reliability, it was thought HOV lanes could encourage the formation of carpools and increase the people moving capacity of congested transportation networks. There is a growing debate as to whether or not HOV lanes have delivered on their promises (Boriboonsomsin and Barth 2008, Kwon and Varaiya 2008, LAO 2000); with some suggesting that congestion could be decreased by converting the HOV lanes to general purpose lanes. It was clear that in some areas of California, HOV lanes had excess capacity even when the neighboring general-purpose lanes were congested.

One way to use the excess capacity was to encourage the purchase of clean air vehicles by allowing them to drive on HOV lanes without meeting minimum-capacity requirement. This was first done for inherently low-emission vehicles³ (ILEVs) in the

¹ Financial Support was provided by the University of California Toxic Substances Research & Teaching Program through the Atmospheric Aerosols & Health Lead Campus Program. Research Assistance was provided by Zachary Prieston and Linh Dang.

1990 Clean Air Act Amendments and the 1998 Transportation Equity Act for the 21st Century (TEA-21). In the 2005 SAFETEA-LU⁴ transportation bill, these privileges were expanded to hybrid vehicles and other low emission and energy efficient vehicles. While the EPA published guidelines for ILEVs and energy efficient vehicles, it was left to the states to identify vehicles and enforce regulations.

California chose to go beyond the ILEV program and promote ultra low emission vehicles (ULEV) and super-ultra low emission vehicles (SULEV) as part of the state's Low Emission Vehicle programs (LEV and LEV II). First, California allowed SULEVs to use HOV lanes without the occupancy constraint. In September of 2004, Governor Schwarzenegger signed Assembly Bill 2628 (AB 2628) to allow hybrids and other vehicles meeting the state's advanced technology partial zero emission vehicle (AT PZEV) standard and having a 45 mpg or greater fuel efficiency rating⁵. Three hybrid vehicles met the requirements: the Honda Civic hybrid, the Honda Insight and the Toyota Prius. All model years of these vehicles were made eligible for a yellow Clean Air sticker, shown in Figure 1. While other Honda, Toyota, Ford and GM hybrids were available and met the AT PZEV standard, they were below the fuel efficiency standard and were thus not qualified for the sticker.



Figure 1: Yellow Clean Air Stickers issued by the California DMV to AT PZEV hybrid vehicles

² HOV or carpool lanes are separate lanes restricted to vehicles carrying a driver with one or more passengers. Theoretically an HOV lane can move at higher speeds and carry more passengers than a general purpose lane. HOV lanes are also known as express lanes, diamond lanes, commuter lanes or transit lanes.

³ ILEVs are a subcategory of clean-fuel vehicles certified by the EPA as meeting LEV exhaust emissions standards and having low levels of evaporative emissions. They are generally non-gasoline/diesel vehicles powered instead by a fuel system such as compressed natural gas, liquid natural gas, liquefied petroleum gas, hydrogen, ethane, methane, solar and battery-electricity.

⁴ Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users

⁵ Additionally, 2004-model year or older hybrids with a 45 mile or greater fuel economy rating and meeting either the SULEV, ULEV (ultra low emission vehicles) or PZEV standards.

The expansion in HOV lane privileges was thought to be a win-win situation to improve air quality by encouraging low emission vehicles and to reduce congestion by using the excess capacity of HOV lanes. All of this without any direct costs to the state. California's Department of Motor Vehicles (DMV) was directed to issue 75,000 Clean Air stickers to qualifying hybrid vehicles in two installments. Once the first installment of 50,000 stickers was issued, the DMV would have to make a determination as to whether or not the HOV lanes had become degraded. If HOV lanes were not found to be degraded, the DMV would issue an addition 25,000 stickers under AB 2628. The DMV charged \$8 per set of stickers to recoup their administrative costs. In September 2006, AB 2600 expanded the number of stickers by 10,000 and extended the program end date to January 11, 2011. In February of 2007, the DMV ran out of these stickers and the only way to obtain one was by buying a used car that had stickers on it. The sticker could be transferred to the car's new owner, but the stickers could not be transferred between vehicles. With AB 1209 chaptered in September, 2008, the policy was changed once again. Effective January 1, 2009, the DMV was allowed to issue Clean Air Stickers to the original owners of qualifying hybrids to replace hybrids that have been declared nonrepairable or total loss salvage.

California's HOV Network

California has a network of over 1,000 miles of HOV lanes and is building more. The network is spread between the four metropolitan areas of Los Angeles, San Diego, San Francisco and Sacramento and depicted in Figure 2. The Los Angeles area has the greatest lane miles of toll roads, and the worst congestion of the four areas. In the Bay Area, carpools, SULEVs and ILEV's receive toll free passage on any of the eight Bay Area bridges (the Antioch, Benicia-Martinez, Carquinez, Dumbarton, Richmond-San Rafael, San Mateo-Hayward, San Francisco-Oakland, and Golden Gate) but hybrids are supposed to pay the toll (BATA 2009, Golden Gate Bridge 2009). It may be the case that hybrid drivers are using the bridges without paying tolls as discussion threads on PriusChat⁶ and listings on Autotrader⁷ included "free tolls" as one of the benefits of a Clean Air sticker. Commute-sheds between these areas are difficult to delineate. Commuters often live in Sacramento and work in San Francisco while the Los Angeles area encompasses areas as diverse as Riverside and Santa Monica. San Francisco and Los Angeles are separated by fewer than 400 miles, which takes approximately six hours to drive. Large differences in the value of a Clean Air sticker should theoretically equalize (net transportation costs) between the metropolitan areas.

The value drivers place on using these HOV lanes depends on the level of congestion on the general purpose lane versus the HOV lane, the travel time savings from using an HOV lane, the increased reliability in travel time as well as whether or not the user feels safer in an HOV lane. In the Bay Area, commuters who carpool report travel time savings of approximately 17 minutes each way in 2005 (RIDES Associates 2005). This is a self-reported time estimate based on phone surveys of commuters. Engineering estimates of

⁶ <http://priuschat.com/>

⁷ <http://www.autotrader.com/>

travel time savings vary depending on the network. Brownstone et al. (2007) find average speed differences between HOV lanes and general-purpose lanes to be approximately 10-30% across highways in Orange County, California. In the Bay Area, Kwon and Varaiya (2008) find that HOV lanes provide only minimal travel time savings but do provide better reliability.

Day-to-day values of travel time savings and increasing travel time reliability have been calculated using the results of demonstration road pricing programs in Southern California (Brownstone and Small 2005, Steinmetz and Brownstone 2005, and Brownstone et al. 2003). All of these studies focus on revealed preference data gathered from SR-91X in Orange County and a stretch of I-15 in San Diego. In Orange County, SR-91X charges preset but time variable fees to drive on an express lane that bypasses the congested general purpose. In northern San Diego, solo drivers can pay a time varying toll calculated to maintain a level of free flow to travel in the HOV lanes on an 8-mile segment of I-15.



Figure 2: HOV Lanes in California

These analyses on SR-91X and I-15 reveal the value of time to be approximately \$20-40 per hour and are able to estimate the value of reliability. In contrast, this study will calculate the annualized value of being able to use HOV lanes. A per hour measure of value of travel time savings will be calculated, but only as a rough check on the validity of the result. The value of the sticker will be estimated using a hedonic model, described in the next section.

Hedonic Pricing Model

Hedonic pricing provides a method for decomposing an item into characteristics and estimating the contributory value of each characteristic. Court (1939) and Griliches (1971) are examples of early hedonic models, both of which were applied to cars. Hedonic models have been applied to a wide variety of goods, in particular housing where the environmental economics literature has used the hedonic method to estimate the costs of air pollution by examining the price premium of living in an unpolluted area (Palmquist 2003, Smith and Huang 1993).

Using Rosen's notation (Rosen 1974), any car can be represented by the n characteristics of that car, $\mathbf{z} = (z_1, z_2, \dots, z_n)$. The equilibrium price of a car is then a function of the characteristics that car contains, $P(\mathbf{z}) = P(z_1, z_2, \dots, z_n)$. Consumers can choose the price they pay for a used car by making decisions on the types and quantities of characteristics to consume, but are price takers on the pricing of the individual components. Equilibrium prices are determined by consumer tastes and producer costs in any particular market, with market clearing conditions further explained in Rosen (1974).

Since the object of interest in this study is the value of a Clean Air sticker, other characteristics are introduced only as a control. The value of a Clean Air sticker is assumed to be linear and not a function of other car characteristics. This assumption will be tested once more data on used car prices have been gathered. The price of a used car can thus be written as $P(\mathbf{z}) = P_{sticker}(sticker) + P(z_1, z_2, \dots, z_{n-1})$ with the second term on the right hand side being represented by various specifications. This relationship will be estimated after a description of the sources and structure of the data.

Evolution of the Sticker Price over Time

The first set of regressions will allow the value of a sticker to vary with each time period, however this type of empirical specification, while flexible, sacrifices precision. We can estimate a parametric model that is consistent with how we expect the value of a sticker to evolve over time. Assuming that a sticker provides a service in each time period that is valued at c_t we can calculate the net present value of the sticker and the value of present and future services at time t as:

$$NPV(t) = \int_t^T c_s e^{-rs} ds$$

Where T is the date at which the program will end and r is the rate of time preference. If the stickers are available at the DMV for \$8, they should capture a premium of more than \$8 plus some administrative cost. It may be the case that the stickers are anticipated to take on value and they are worth more than this, in which case we model that value as V_1 . Assuming $c_t=c$ for all t after February 2007, we can integrate and rewrite the NPV at any point in time as being a function of the initial value $V_2 = \frac{c}{r} e^{-rT}$ and a component that decreases as t approaches T , $V_3(t) = \frac{c}{r} e^{-rt}$ making the value of a sticker at time t :

$$WTP(t) = \begin{cases} V_1 & \text{if } t < \text{February 2007} \\ V_2 - V_3(t) & \text{if } t \geq \text{February 2007} \end{cases}$$

In the empirical section of this paper we will model the willingness-to-pay for a California Clean Air Sticker as decreasing over time, both as a linear time trend and as a non-linear function as capital theory would suggest.

DESCRIPTION OF THE DATA

Data were gathered and are still being gathered from three sources: completed Ebay auctions, Autotrader.com, and the classified sections of three major metropolitan newspapers (the Sacramento Bee, the San Francisco Chronicle and the San Diego Union-Tribune). Attempts are being made to acquire classified ads from the Los Angeles Times. The breakdown of this data is presented in Table 1. Data were gathered from Autotrader.com and Ebay manually for the month of May and July 2008, and using a PERL program from October 2008 to May 2009. While PERL and later Stata could

Data Source	Number of Observations	Percentage of Data	Dates Covered in Data Segment
Ebay	120	3.5	May 2008, July 2008, Oct 2008 through May 2009
Autotrader.com	2,997	88.3	May 2008, July 2008, Oct 2008 through May 2009
Newspaper Data	279	8.2	Dec 2006 – March 2009
Sacramento Bee	137	4.0	Dec 2006 – March 2009
San Francisco Chronicle	118	3.5	Dec 2006 – May 2008
San Diego Union-Tribune	24	0.7	Dec 2006 – May 2007
Total	3,393		Dec 2006 – May 2009

Table 1: Sources of Data and Date

pick out important features of the cars through text searches, the presence of a Clean Air sticker was not always listed in the description and so pictures of each car were examined as an additional check for the presence of a sticker. Data from newspaper classifieds were gathered using microfiche collections and entered into Excel. Microfiche are not available immediately so there is a lag between the current date and the microfiche

available. All of the dates available as of May 21, 2009 have been gathered from the Sacramento Bee, while information is still being entered for the San Francisco Chronicle and the San Diego Union-Tribune. As microfiche from May 2008 become available, these observations will be added to the dataset. While the dataset is currently incomplete, important and interesting patterns can still be observed.

When a vehicle was listed for multiple weeks, the most recent listing of that vehicle was used. It was simple to determine which observations were duplicates from Autotrader and Ebay since each website provided a unique Vehicle Identification Number (VIN) for each car. With the newspaper data, the phone number for each classified advertisement was collected. When the same phone number was found twice in the data, the classified advertisements were compared. If the make, model, year and mileage of the vehicles

Data Sources		Month and Year	# of Observations	Season	
Sacramento Bee	San Francisco Chronicle	San Diego Union-Tribune	December 2006	21	1
			January 2007	32	
			February 2007	32	
			March 2007	24	2
			April 2007	5	
			May 2007	20	
		June 2007	4	3	
		July 2007	5		
		August 2007	19		
		September 2007	10	4	
		October 2007	14		
		November 2007	16		
	December 2007	9	5		
	January 2008	7			
	February 2008	4			
	March 2008	6	6		
	April 2008	6			
	AutoTrader and Ebay	May 2008	85	7	
		June 2008	16		
		July 2008	142		
		August 2008	7	8	
		September 2008	-		
		October 2008	61	9	
		November 2008	216		
		December 2008	258		
	AutoTrader and Ebay	January 2009	469	10	
		February 2009	330		
		March 2009	388		
		April 2009	454	10	
		May 2009	737		

Table 2: Number of Observations by Date

were identical the vehicles were treated as duplicates. Because some cars were listed for longer than a month and May was the last month where data were collected, there are more observations in May 2009 than in November 2008 through April 2009, despite using the same data gathering technique for these months. The number of observations from each month is shown in Table 2. Since there were so few observations for months where the dataset is incomplete, the months were grouped into ten seasons of three months each. These were Winter (December through February), Spring (March through May), Summer (June through August) and Fall (September through November). Seasonal breakdowns are also included in Table 2.

There are important differences between Ebay and Autotrader/newspaper data. The prices on Autotrader and in the newspapers are asking prices, while the prices on Ebay are final prices resulting from a completed auction. Table 3 compares the mean price across sources, and it can be seen that prices on Ebay are approximately \$5,000 lower than prices from Autotrader and newspaper prices. When assembling the data and looking for duplicates, some cars were listed on Autotrader but sold on Ebay and the final auction price on Ebay was usually lower than the asking price on Autotrader. Average mileage differs between the three sources, most dramatically between newspaper in which the average mileage is 32,900 miles and the two internet sources in which the average mileage is 44,700 miles for Ebay cars and 44,200 for Autotrader cars. This is likely to do with reporting bias, almost a third (30 percent) of newspaper classified ads did not report the mileage of the car, while with AutoTrader and Ebay, that number was much lower, one percent and six percent respectively. Eleven percent of newspaper classified ads listed mileage as “low” but did not give a number. For these, mileage was coded as zero, but a dummy variable was included in the regression. Inclusion of these observations did not significantly change the estimate of the price of a Clean Air sticker. Another important difference between data sources is the high percentage of cars from Ebay with a salvage title. This is likely not the result of reporting bias. All 62 observations from Autotrader for the month of May 2008 were checked for a salvage title using CarFax⁸ and only one unreported salvage title was found. It may be that Ebay is an important marketplace for salvaged and damaged cars. The percentage of the three models of cars was similar across sources.

Data Source	Price	Mileage	% HOV	% Salvage	% Prius	% Insight	% Civic
Ebay	\$13,000	44,700	27	53	77	6	17
Autotrader.com	\$18,300	44,200	16	1.1	73	0.7	26
Newspaper	\$18,100	32,900	20	0.3	69	2	29

Table 3: Descriptive Data By Source

Information on each car’s location was collected; for newspaper data, the location was assumed to be the same as where the newspaper was based, San Francisco, Sacramento or San Diego. For Autotrader and Ebay data, either the address was given or the dealer’s name was listed and later located using Google. These observations were then aggregated

⁸ www.carfax.com

by metropolitan region and two rural regions, rural Northern California and the Central Valley. The individual cities and the regional groupings are pictured in Figure 3. Summary statistics by region are presented in Table 4. In the data, 22.6 percent of cars for sale in the Los Angeles area had a Clean Air Sticker. San Francisco was behind with 17.0 percent with Sacramento and San Diego coming in at similar 12.7 and 12.2 percents. In the Central Valley, 5.2 percent of cars have HOV stickers while no cars in our data set had stickers in Northern California. This is not surprising since there are no HOV lanes in the Central Valley or Northern California. The price of used cars is higher in the rural areas than the urban areas, but mileage was similar across geographic regions. This may be due to greater competition across dealers and sellers in higher density urban regions or because of the greater wear and tear urban areas have on cars.

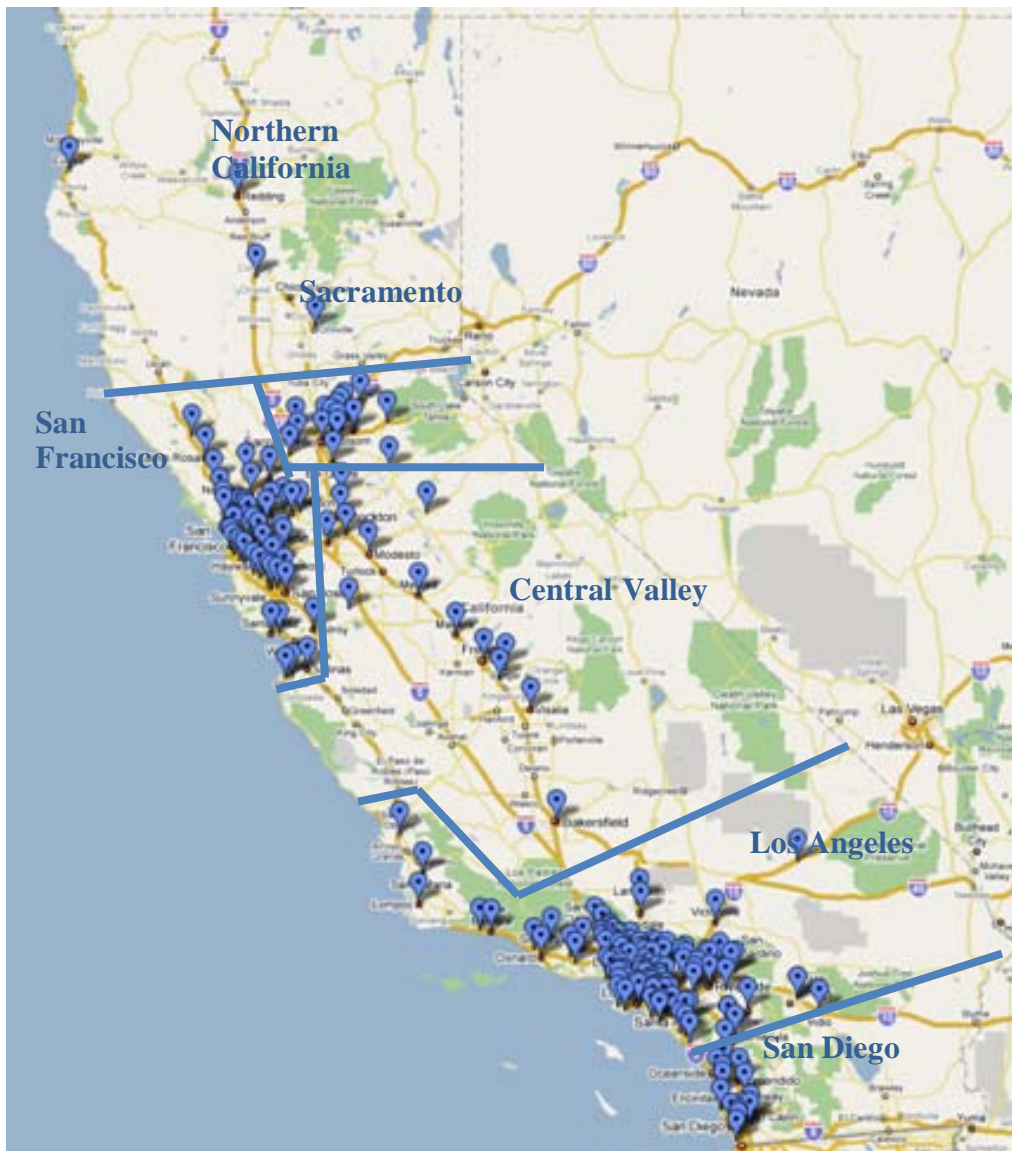


Figure 3: Location of Cars and Regional Breakdown

Location	# of Observations	% HOV	Average Price	Average Mileage
Los Angeles	1,509	22.6	\$16,600	50,500
San Diego	304	12.2	\$17,900	44,400
San Francisco Bay Area	892	17.0	\$18,600	46,600
Sacramento	371	12.7	\$16,900	41,800
Central Valley	153	5.2	\$17,600	52,500
Northern California	37	0.0	\$17,800	45,800

Table 4: Observations by Region

Of the three hybrid models eligible for the Clean Air sticker, the Prius was most frequently found in this dataset. The Prius sold for a higher price than the other cars, and was more likely to have a navigation system. The Civic was more likely to have an HOV sticker. The Honda Insight had the lowest price and the highest mileage, a result of the Insight having been in production longer (since 2000 as opposed to 2001 for the Prius in the U.S. and 2003 for the Civic). Honda discontinued production of the Insight in 2006, but has recently come out with a 2010 model which is being advertised as the cheapest hybrid car on the market.

Model	# of observations	Average Price	Average Mileage	% HOV	% with Navigation System
Toyota Prius	2,938	\$18,900	41,200	13.8	16.8
Honda Civic	1,009	\$16,100	50,200	22.7	12.4
Honda Insight	37	\$11,200	80,800	32.4	0.0

Table 5: Car Characteristics by Model

The Toyota Prius has two major redesigns represented in the data. The first Prius introduced in the United States is the 2001 model. The 2004 Prius was re-designed to be more spacious. The first generation Insight was produced only from 2000 through 2006 with total global sales reaching approximately 18,000 cars. The Civic Hybrid was not introduced until 2002 as a 2003 model based on the seventh generation Civic. The Civic Hybrid is currently in its second generation, the first being from 2003 until 2005 and a re-design for the 2006 model which remains at present. The Prius is the most common make of car represented in the data, seconded by the Civic while the Insight is rare.

Model Year	# of observations	# of Prius	# of Civic	# of Insight	Average Price	Average Mileage	% HOV
2000	6			6	\$8,300	110,000	66.7
2001	82	71		11	\$9,700	96,300	23.2
2002	113	108		5	\$11,100	90,900	20.3
2003	233	79	148	6	\$12,200	76,800	22.3
2004	347	201	145	1	\$15,400	68,300	32.5

2005	726	568	156	2	\$17,300	57,600	29.6
2006	577	350	221	6	\$19,100	43,700	30.3
2007	1,309	1,061	248		\$19,700	29,300	3.6

Table 6: Car Characteristics by Model Year

Perhaps one of the most striking differences between cars with and without a Clean Air sticker is the difference in mileage, presented in Table 7. While the prices of each group are similar, the mileage of cars with a sticker is almost 50 percent higher than cars without. Cars with a sticker tended to be older than cars without a sticker, and they had more miles per year driven. This could be because being able to drive on HOV lanes makes driving less costly and more enjoyable. More likely, people who expect to heavily use their cars applied for a sticker. Either explanation points to the need to include mileage in any estimate of sticker value since it is correlated with the Clean Air Sticker and an important component of price.

	Price	Average Age of Car	Average Mileage	Average Mileage/Age
Cars with a Clean Air Sticker	\$17,300	3.7	66,300	18,500
Cars without a Clean Air Sticker	\$17,600	3.0	44,300	15,800
All Cars	\$17,600	3.2	48,400	16,300

Table 7: Average Price and Mileage for Cars With and Without Clean Air Stickers

EMPIRICAL MODEL

The price of used car i at time t is assumed to be a function of whether or not it has a Clean Air sticker, the type of car (make, model, year, etc.), the condition of the car (captured by mileage), the accessories that come with the car, where the seller is located and whether or not financing is available:

$$Price_{it} = f(\text{sticker}_i, \text{characteristics}_{it}, \text{condition}_{it}, \text{accessories}_i, \text{location}_{it}, \text{financing}_{it})$$

Price is transformed into the natural log of price, while the type of car is captured by model year, and model type (Prius, Civic or Insight). While many cars were listed as being in “excellent” or “perfect” condition, there was no objective way to grade the condition of the cars and so the mileage and whether or not the car had a salvage title was assumed to sufficiently capture the condition of the car but further iterations of this data set. The impact of descriptive words such as “excellent”, “perfect” or “mint” on price was examined for a subset of the data to no effect. The options package associated with a particular car was not always listed. Instead, to represent some of the important packages for the Prius and the Civic, variables available in the upgraded packages were included such as whether or not a vehicle came with a built-in navigation system, an enhanced stereo system (JBL) with an mp3 hook-up and bluetooth capabilities. Six dummies for the

location of the car were included to capture location. This was assumed to be sufficient since buying a car is a large decision and consumers are assumed to be willing to drive across town for such a purchase. Another important variable is whether or not the car was listed on Ebay, Autotrader or in the newspaper since Autotrader and the newspaper show asking price while only final prices were used from Ebay. Whether or not a car was sold by a private seller was also deemed to be important since dealerships are more likely to provide warranties and financing than private sellers.

Timing is an important part of sticker value. Until the DMV stopped issuing Clean Air stickers (February 2007), or was expected to stop issuing the stickers, the stickers should not have been worth more than the \$8 it cost to acquire them from the DMV. Once the initial 75,000 stickers had been issued, there were discussions on PriusChat anticipating when the additional 10,000 stickers would also run out. Since the privileges associated with a Clean Air sticker are expected to expire on January 1, 2011, the value of a sticker should be decreasing with time. Three specifications for the price of a sticker are used. First, dummies are used for each season; and second, a time trend is fitted to the value of the sticker and the third specification allows the time trend to be non-linear in the parameters. Table 8 presents the five regressions using these three types of time trends. The first regression looks at how the sticker changes over time but does not allow the coefficient on vehicle model year or the coefficient on mileage to change over time:

$$\begin{aligned}
 \ln(\text{Price}_{it}) = & \alpha + \beta_1 \text{sticker}_i + \beta_2 \text{mileage}_i + \sum_{j=1}^3 \beta_{3,j} \text{model}_{ij} \\
 & + \sum_{j=2000}^{2007} \beta_{4,j} \text{modelyear}_{ij} + \beta_5 \text{bluetooth}_i + \beta_6 \text{mp3}_i \\
 & + \beta_7 \text{navigation system}_i + \sum_{j=1}^5 \beta_{8,j} \text{source}_{ij} + \sum_{j=1}^6 \beta_{9,j} \text{location}_{ij} \\
 & + \sum_{j=1}^{10} \beta_{10,j} \text{season}_{ij} + \varepsilon_i
 \end{aligned}$$

The second regression includes everything in the first regression but allows the coefficient on model year to change over time as well as the coefficient on mileage to change each year. We run a second model where the value of the sticker over time evolves linearly:

$$\begin{aligned} \ln(\text{Price}_{it}) = & \alpha + \beta_1 \text{sticker}_i + \beta_2 \text{sticker}_i t + \beta_3 \text{mileage}_i + \sum_{j=1}^3 \beta_{4,j} \text{model}_{ij} \\ & + \sum_{j=2000}^{2007} \beta_{5,j} \text{modelyear}_{ij} + \beta_6 \text{bluetooth}_i + \beta_7 \text{mp3}_i \\ & + \beta_8 \text{navigation system}_i + \sum_{j=1}^5 \beta_{9,j} \text{source}_{ij} + \sum_{j=1}^6 \beta_{10,j} \text{location}_{ij} \\ & + \sum_{j=1}^{10} \beta_{11,j} \text{season}_{ij} + \varepsilon_i \end{aligned}$$

The fourth and fifth regressions in Table 8 use a non-linear specification for how the price of the sticker changes through time. Non-linear estimation was used to estimate both β_2 and r . The fourth regression includes car characteristics, seasonal and regional dummies on the price of the car, but excludes the seasonal dummies interacted with the sticker dummy variable and is represented below.

$$\begin{aligned} \ln(\text{Price}_{it}) = & \alpha + \beta_1 \text{sticker}_i + \beta_2 \text{sticker_season}_1_i + \beta_3 \text{sticker}_i e^{rt} + \beta_4 \text{mileage}_i \\ & + \sum_{j=1}^3 \beta_{5,j} \text{model}_{ij} + \sum_{j=2000}^{2007} \beta_{6,j} \text{modelyear}_{ij} + \beta_7 \text{bluetooth}_i + \beta_8 \text{mp3}_i \\ & + \beta_9 \text{navigation system}_i + \sum_{j=1}^5 \beta_{10,j} \text{source}_{ij} + \sum_{j=1}^6 \beta_{11,j} \text{location}_{ij} \\ & + \sum_{j=1}^{10} \beta_{12,j} \text{season}_{ij} + \varepsilon_i \end{aligned}$$

The fifth regression includes everything in the fourth with additional interaction terms for calendar year and model year as well as mileage and calendar year.

	I	II	III	IV	V
	Season-HOV interactions		Linear HOV time trend	Non-linear HOV time trend	
Clean Air Sticker Dec 2006 - Feb 2007	0.106** (2.10)	0.129** (2.44)		-0.13 (1.44)	-0.251** (2.35)
Clean Air Sticker March – May 2007	0.171*** (3.59)	0.157*** (3.56)			
Clean Air Sticker June – August 2007	0.313*** (3.70)	0.329*** (3.51)			
Clean Air Sticker Sept – Nov 2007	-0.044 (0.89)	-0.055 (1.10)			
Clean Air Sticker	0.065	0.052			

Dec 2007 - Feb 2008	(1.17)	(1.05)			
Clean Air Sticker March – May 2008	0.134*** (3.78)	0.141*** (4.02)			
Clean Air Sticker June – August 2008	0.137*** (3.90)	0.140*** (3.82)			
Clean Air Sticker October – Nov 2008	0.096*** (4.68)	0.058** (2.51)			
Clean Air Sticker Dec 08 – Jan 2009	0.070*** (4.00)	0.067*** (3.87)			
Clean Air Sticker Feb - May 2009	0.095*** (5.92)	0.100*** (6.23)			
Clean Air Sticker Intercept			0.131*** (3.31)	0.242*** (3.43)	0.402*** (4.76)
Clean Air Sticker – Linear Time Trend			-0.0004 (1.05)		
r				-0.009*** (3.06)	-0.013*** (5.71)
Mileage	-4.87E-06*** (25.88)	-2.01E-06*** (0.46)	-3.10E-06*** (0.72)	-4.86e-06*** (34.68)	-4.18e-06*** (3.87)
Low	-0.200*** (3.81)	-0.182*** (3.18)	-0.160** (2.45)	-0.184*** (3.49)	-0.182*** (2.97)
Insight Dummy	0.089*** (3.09)	0.105*** (3.35)	0.110*** (3.57)	0.089*** (2.75)	0.094*** (2.82)
Prius Dummy	0.119*** (15.35)	0.119*** (15.38)	0.119*** (15.44)	0.120*** (16.00)	0.121*** (15.86)
2001 Model Year	0.046 (0.39)	0.465** (2.20)	0.553*** (2.76)	0.05 (0.59)	0.02 (0.14)
2002 Model Year	0.108 (0.91)	0.560** (1.96)	0.607** (2.16)	0.11 (1.39)	0.06 (0.20)
2003 Model Year	0.211* (1.79)	0.666*** (4.17)	0.679*** (4.48)	0.212*** (2.68)	0.19 (1.51)
2004 Model Year	0.385*** (3.28)	0.625*** (2.93)	0.645*** (3.06)	0.386*** (4.87)	0.301** (2.22)
2005 Model Year	0.430*** (3.66)	0.727*** (4.36)	0.789*** (5.84)	0.432*** (5.46)	0.323** (2.48)
2006 Model Year	0.492*** (4.18)	0.694*** (6.62)	0.677*** (7.31)	0.494*** (6.22)	0.20 (0.96)
2007 Model Year	0.477*** (4.05)	0.785*** (6.18)	0.670*** (4.90)	0.479*** (6.01)	0.300** (2.44)
JBL Premium Sound System	0.046*** (4.02)	0.044*** (3.81)	0.044*** (3.78)	0.047*** (3.23)	0.046*** (3.08)

Leather Interior	0.015 (1.13)	0.013 (0.96)	0.012 (0.90)	0.02 (0.96)	0.004 (0.22)
Car described as 'Loaded'	-0.042*** (2.69)	-0.045*** (2.86)	-0.043*** (2.76)	-0.042*** (2.94)	-0.056*** (3.86)
Bluetooth Enabled	-0.033** (2.13)	-0.033** (2.07)	-0.034** (2.17)	-0.035* (1.87)	-0.036* (1.92)
Mp3	0.041*** (4.37)	0.040*** (4.34)	0.041*** (4.42)	0.041*** (3.52)	0.043*** (3.58)
Navigation System	0.035*** (3.78)	0.034*** (3.69)	0.034*** (3.69)	0.034*** (3.45)	0.023** (2.23)
AutoTrader (ebay omitted)	0.367*** (13.34)	0.360*** (12.96)	0.370*** (13.49)	0.362*** (20.17)	0.338*** (18.41)
Sacramento Bee	0.288*** (6.21)	0.300*** (6.56)	0.295*** (6.51)	0.285*** (7.79)	0.269*** (7.82)
San Diego Union- Tribune	0.416*** (6.94)	0.415*** (6.93)	0.401*** (6.86)	0.413*** (7.23)	0.408*** (7.18)
San Francisco Chronicle	0.255*** (4.67)	0.268*** (5.04)	0.258*** (4.82)	0.248*** (5.53)	0.245*** (5.75)
Los Angeles Dummy	-0.036 (1.41)	-0.043* (1.67)	-0.035 (1.51)	-0.02- (1.10)	-0.01- (0.76)
San Diego Dummy	-0.072*** (2.69)	-0.078*** (2.87)	-0.071*** (2.85)	-0.057*** (2.84)	-0.048** (2.43)
San Francisco Dummy	-0.046* (1.79)	-0.050* (1.95)	-0.042* (1.79)	-0.03 (1.59)	-0.02 (1.01)
Sacramento Dummy	-0.094*** (3.38)	-0.097*** (3.47)	-0.091*** (3.49)	-0.080*** (3.71)	-0.072*** (3.38)
Central Valley Dummy	-0.012 (0.46)	-0.017 (0.63)	-0.011 (0.44)	0.00 (0.13)	0.02 (0.78)
Northern California Dummy	0.027 (0.79)	0.019 (0.56)	0.028 (0.84)	0.04 (1.24)	0.03 (0.89)
Sold by Dealer	0.081*** (3.73)	0.085*** (3.86)	0.075*** (3.43)	0.089*** (8.79)	0.057*** (5.79)
Season Dummies	Yes	Yes	Yes	Yes	Yes
Calendar Year - Model Year Interaction Dummies	No	Yes	Yes	No	Yes
Calendar Year Dummies Interacted with Mileage	No	Yes	Yes	No	Yes
Constant	9.254*** (68.96)	8.796*** (70.91)	8.818*** (77.38)	9.241*** (98.63)	9.289*** (74.78)
Observations	2863	2863	2863	2863	2863
R-squared	0.73	0.74	0.73	0.73	0.72

Table 8: Regression of Car Characteristics on Ln(Price)

Robust t statistics in parentheses ** significant at 5%; *** significant at 1%

Controlling for characteristics of the car is important if they are correlated with the presence of the sticker. Drivers that expect to use their car heavily will be more likely to apply for a sticker and may want a car with more extras such as a sound or navigation system. A built-in navigation system is worth approximately \$600 or approximately 3 percent of the price of the car, significantly less than the dealership price differential of \$2,000 for cars with and without a navigation system. Of the regional dummies, only the urban areas had significant coefficients, most of them negative suggesting higher competition in urban areas or because cars in rural and suburban settings are generally in a better condition than those in urban areas. Seasonal dummies, and interaction terms are not presented, but they are as expected. A 2000 model car is worth less in 2007 than it was in 2006. A car with a lot of mileage in 2006 is worth less than a similar car with a lot of mileage in 2007. This is because an eight year-old car with 100,000 miles on it is expected, while a three year-old car with similar mileage has undergone heavy use. While these results are not relevant to the price of the sticker, they do lend credibility to the model.

For the seasonal dummy models (regressions I and II), understanding how the sticker value changes over time is straight-forward. The estimated value of the Clean Air sticker is approximately \$5,900 in the summer of 2007 using a mean vehicle price of \$18,000. It is curious that the sticker was worth about half as much the three months before when the stickers had run out. This could be a problem of dealers and drivers not understanding the value of the sticker.

There are some seasons where the price of the sticker is not significant but this is likely due to the paucity of observations during those time periods. Delays in getting newspapers to microfiche have made that data unavailable at the time of analysis, but hopefully additional data from the San Francisco Chronicle, the San Diego Union-Tribune and hopefully the Los Angeles Times will fix this problem. One curious note is that the sticker actually increases in value between Spring and Summer of 2008, possibly due to the sharp rise in gas prices during this period. These gas prices increased the demand for energy efficient vehicles and increased the gains to avoiding traffic congestion. It appears as if the price of a sticker rose in February through May 2009. This may be an empirical blip, it might represent the observations in May that will still be for sale in June, or it might be because of the change in policy that allows owners of nonrepairable/salvage hybrids with sticker to transfer the sticker to a new qualifying hybrid. Using the last set of data from the first two regressions, in May 2009, the price of the sticker is approximately \$1,700.

To understand the differences between the models and see how the stickers change over time in the linear and non-linear models, five graphs plot the value of the sticker over time. The first two specifications, I and II, represent how the price evolves under the two models allowing the sticker to vary each season. The third (green) line is the linear

specification; while the teal and purple lines (regressions IV and V) represent the non-linear specifications.

It is interesting how different the fourth and fifth regressions appear when plotted. This might be because not controlling for mileage-time and model year-time interaction effects under-states the value of a sticker since stickers are more likely to be found on older cars with higher mileage. The fifth non-linear and the non-parametric specifications match up nicely. The peak in the plot of regression V corresponds to a sticker price of \$6,100. This is likely the best estimate of the willingness to pay for a California Clean Air sticker at the height of the program. Regression V matches up nicely with the non-parametric estimates and fits within the range of value of time estimates to be discussed in the next section.

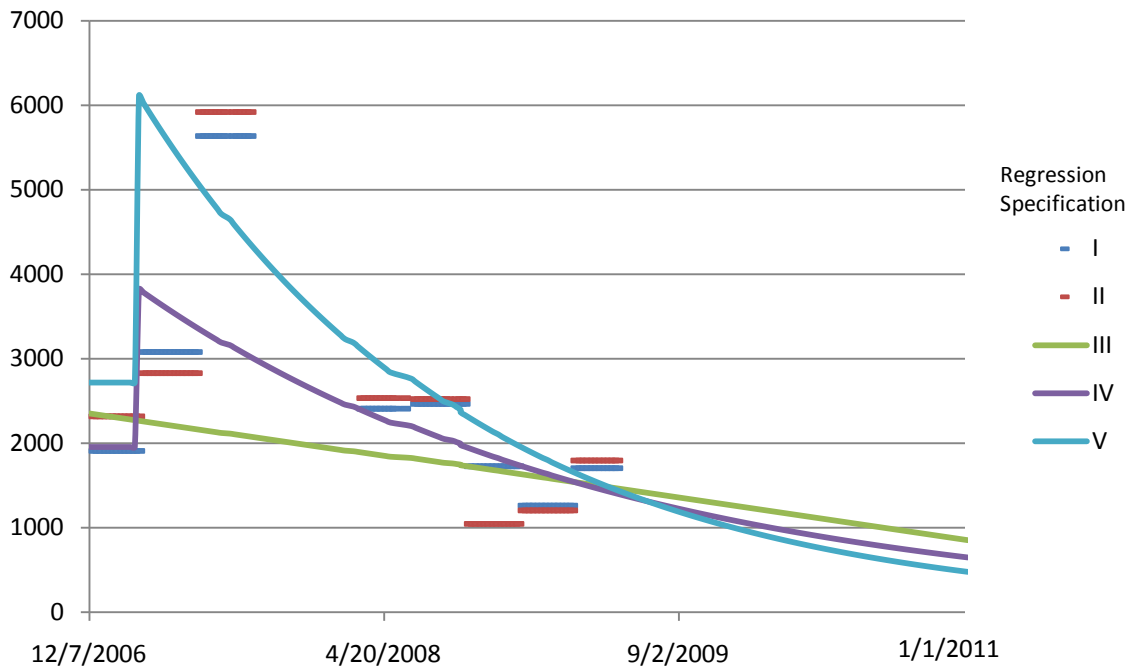


Figure 4: Evolution of the Willingness to Pay for a California Clean Air Sticker

Of additional interest is whether or not a Clean Air sticker is worth more in certain metropolitan areas. We use the linear and non-linear specifications, adding interaction terms for location. Regression II from Table 9 is specified below:

$$\begin{aligned}
\ln(\text{Price}_{it}) = & \alpha + \beta_1 \text{sticker}_i + \beta_2 \text{sticker_season}_1_i + \beta_3 \text{sticker}_i e^{rt} \\
& + \sum_{j=1}^6 \beta_{4,j} \text{location}_{ij} + \beta_5 \text{mileage}_i + \sum_{j=1}^3 \beta_{6,j} \text{model}_{ij} \\
& + \sum_{j=2000}^{2007} \beta_{7,j} \text{modelyear}_{ij} + \beta_8 \text{bluetooth}_i + \beta_9 \text{mp3}_i \\
& + \beta_{10} \text{navigation system}_i + \sum_{j=1}^5 \beta_{11,j} \text{source}_{ij} + \sum_{j=1}^6 \beta_{12,j} \text{location}_{ij} \\
& + \sum_{j=1}^{10} \beta_{13,j} \text{season}_{ij} + \varepsilon_i
\end{aligned}$$

The results of this regression, presented in Table 9, are similar to the regression above. The value of the Clean Air sticker does appear to differ across locations. Cars with a Clean Air sticker were not observed in the rural areas of Northern California, so that dummy variable was dropped. The sticker is more valuable in Los Angeles than any other area, and the San Francisco and Sacramento areas are not statistically different from one another while a t-test reveals that San Diego and Los Angeles are different at a 5 percent significance level. These results suggest sellers can reap gains by moving vehicles with Clean Air stickers from the Sacramento into San Diego. While an individual in Sacramento may not want the hassle of selling a car to someone in San Diego, dealerships should be able to arbitrage out differences minus transportation costs.

	I	II	III
	Linear HOV time trend	Non-Linear HOV time trend	
Clean Air Sticker Dec 2006-Feb 2007		-0.179* (1.84)	-0.347*** (3.16)
Clean Air Sticker Intercept		0.399*** (4.88)	0.643*** (6.99)
Clean Air Sticker Slope	-0.001*** (2.73)		
r		-0.009*** (3.91)	-0.012*** (6.22)
Clean Air Sticker Los Angeles	-0.04 (1.09)	-0.04 (1.29)	-0.052* (1.69)
Clean Air Sticker San Diego	-0.083* (1.77)	-0.082** (2.00)	-0.098** (2.37)
Clean Air Sticker San Francisco	-0.110*** (2.92)	-0.110*** (3.32)	-0.116*** (3.44)
Clean Air Sticker Sacramento	-0.146** (2.26)	-0.143*** (3.08)	-0.239*** (5.04)

Clean Air Sticker Central Valley	-0.08 (1.04)	-0.08 (1.26)	-0.09 (1.42)
Location Dummies	Yes	Yes	Yes
Car Characteristics Controls	Yes	Yes	Yes
Season Dummies	Yes	Yes	Yes
Calendar Year - Model Year Interaction Dummies	No	No	Yes
Calendar Year Dummies Interacted with Mileage	No	No	Yes
Constant	8.743*** (65.93)	9.186*** (96.99)	9.248*** (74.35)
Observations	2863	2863	2863
R-squared	0.74	0.73	0.72
Table 9: Regressions of Car Characteristics on ln(Price) to Estimate Regional Differences in Clean Air Sticker Value			

Value of Time Estimates

We can solve for c_t , the weekly value of having access to HOV lanes, using the results of regressions IV and V. These regressions suggest that prospective hybrid car buyers are willing to pay between \$40-94 per week for access to HOV lanes. This translates into a willingness-to-pay of \$1,600 (regression IV, Table 8) or \$3,600 (regression V, Table 8) per year of HOV privileges. The value of driving in the HOV lane has many components such as, travel time savings, greater travel time reliability and a greater perception of safety by being able to travel in a less congested lane. None of these effects can be separated using the data collected, but as an empirical check a rough value of travel time savings can be estimated and compared with previous estimates.

Assuming the Bay Area time savings of 17 minutes each way (RIDES Associates 2004), and assuming commuters make two trips a day, five days a week. A Clean Air Sticker values time at \$14-\$33 per hour, similar to the range of \$20-40 per hour found by Brownstone and Small (2005), \$7-25 per hour found by Barrett (2009), \$30 median value of time in Steinmetz and Brownstone and Steinmetz (2005) and 50 percent of the gross wage rate found in Small (1992). The estimates of \$14 or \$33 per hour is likely an underestimate of HOV driving privileges since it is conditional on having to drive one of three hybrid cars and would likely be higher without that constraint.

DISCUSSION

The premium a Clean Air sticker confers on a used car has been noted before in the popular press (NPR 2007) and the program has been viewed with suspicion by carpoolers and by those who do not own hybrid cars (Tierney 2005, Covarrubias 2006). However,

driving a hybrid car is not the only way to gain access to HOV lanes as a single passenger. Motorcycles are exempt from HOV restrictions and more importantly, SULEV and ILEV vehicles can still obtain Clean Air stickers. Finally, this program was not the only way to simultaneously make use of excess capacity in HOV lanes and clean the air. The extent to which other programs could have generated benefits to society better reflect the true opportunity cost of AB 2628. Both of these issues are discussed below.

Implications for Alternative Fuel Vehicles

While the DMV no longer provides yellow Clean Air stickers for owners of Prius, Civic and Insight cars, the DMV does provide white Clean Air stickers (Figure 4) to SULEV and ILEV vehicles for \$8. One model that qualifies for the white Clean Air sticker is the Honda Civic GX. The Civic GX, like the Civic Hybrid, is similar in size and performance to the conventional Civic except that the Civic GX is a dedicated natural gas vehicle. It is powered exclusively on compressed natural gas (CNG), which is cleaner than gasoline or diesel. The CNG vehicle has a higher cost (\$6,830 more, according to Honda) that is comparable to the price premium paid for a Civic Hybrid (Table 10).



Figure 5: White Clean Air sticker issued by the California DMV to SULEV and ILEV vehicles including the Honda Civic

	MSRP Base Price
2009 Honda Civic	\$15,305 - \$25,190
2009 Honda Civic Hybrid	\$23,650 - \$26,850
2009 Honda Civic GX	\$25,190

Table 10: Prices of Honda Civics by Fuel Technology

Source: Honda Cars 2009

The fuel costs of a Civic GX are between 30 to 50 percent of the cost of driving, which is similar to the hybrid. However, refueling can be a hassle with the Civic GX as CNG is not available in all areas; nationwide there are only 300 stations. In addition, the range of a car running on CNG is approximately 200-250 miles, compared with a gasoline powered Civic's range of 400 miles (Consumer Reports 2008). The up-to- \$6,100 price of a Clean Air sticker for hybrid vehicles and the comparable costs and performance of

the Civic Hybrid and Civic GX suggest that consumers are willing to pay at least \$6,100 to avoid the limited range and refueling restrictions of a CNG vehicle.

That consumers who are willing to pay up to \$6,100 for a Clean Air sticker on a hybrid are not willing to switch to a Civic GX with an \$8 sticker has implications for alternative fuel vehicles. Electric cars, hydrogen fuel cells, natural gas and other alternative fuel technologies have these similar problems of range. A liquid fuel such as gasoline or diesel is inherently more energy dense and easier to transport than gaseous fuels such as natural gas and hydrogen while cost-effective battery technologies are currently unable to provide the range of a gasoline powered vehicle. None of these vehicles have the benefit of a network of fueling centers such as gasoline and diesel vehicles do. Even a \$6,100 difference in price is not enough to induce most consumers into choosing a limited range, alternative fuel vehicle over a gasoline-powered vehicle.

Opportunity Costs of Hybrids in HOV Lanes

Granting hybrid cars access to HOV lanes may have seemed like a 'free' way for policy makers to encourage cleaner technologies. With minimal government expenditure they could lessen dependence on oil, but there were two important opportunity costs to this policy. The first cost was an indirect cost. Transportation economists wanted to see the excess capacity used in High Occupancy Toll (HOT) lanes as an experiment in congestion pricing. This opportunity was missed.⁹ The second cost was that the permits clearly had value and the state gave them away.

The estimated value of \$3,600 per year applies only to individuals willing to purchase a used Prius, Insight or Civic Hybrid and is most likely an understatement of the general public's willingness-to-pay for access to California's HOV lanes. The state government could have sold the permits to any type of vehicle for at least \$3,600 per year or \$6,100 if issued in 2007 to expire in 2011. Selling 85,000 permits for \$6,100 would have raised almost \$519 million dollars. At a cost effectiveness standard of \$24,500/ton of NO_x¹⁰, the state could have reduced over 21,000 tons of NO_x. If CO₂ is priced at \$50/ton, the state could have reduced 10.3 million tons of CO₂. How much air pollution did the Clean Air Sticker program reduce? The answer to this question will tell us if the Clean Air Stickers are an effective way to reduce air pollution.

⁹ Although this opportunity was missed, HOT projects are moving forward in California. AB 744 would create an 800-mile Express Way in the Bay Area while HOT projects already exist in Southern California.

¹⁰ Statewide Air Districts use cost-effective thresholds that vary from \$17,500/ton to \$24,500/ton of NO_x when evaluating control technologies. These thresholds are the maximum a control technology may cost to be classified as cost-effective and are an upper bound of pollution reduction costs. (SJV UAPCD 2008)

Hybrid cars produce 90 percent less than the average car. The standard for 2000 model year passenger automobiles was 0.4 grams of NO_x per mile¹¹. If every driver who purchased a hybrid vehicle with a Clean Air sticker would not have purchased a sticker otherwise and those drivers would have driven the same amount¹² with their conventional car, 3,204 tons of NO_x were reduced from 2006 to 2011. If we assume the vehicles lasted 10 years on average, this resulted in 6,408 tons of NO_x.

$$\begin{aligned}\text{NO}_x &= 0.90 \times 0.4 \text{ grams/mile} \times 19,000 \text{ miles/year} \times 10 \text{ years} \times 85,000 \text{ cars} \\ &= 6,408 \text{ tons of NO}_x\end{aligned}$$

If each one of the cars with 45 miles per gallon (0.022 gallons/mile) had been replaced with a conventional car meeting CAFE requirements of 27.5 miles per gallon (0.036 gallons/mile) and each car lasted 10 years, then 604,000 tons of CO₂ was reduced by this program.

$$\begin{aligned}\text{CO}_2 &= 2,421 \text{ grams CO}_2/\text{gallon} \times 0.014 \text{ difference in gallons gasoline/mile} \times \\ &\quad 19,000 \text{ miles/year} \times 10 \text{ years} \times 85,000 \text{ cars} \\ &= 605,000 \text{ tons of CO}_2\end{aligned}$$

Another assumption is that every person buying a hybrid that obtained a Clean Air sticker did so because of the sticker. This assumption is clearly overly conservative as many people are buying hybrid cars even without the incentive. Even under these conservative assumptions, at \$24,500/ton of NO_x and \$100/ton of CO₂, the state could have reduced the same amount of air pollution for \$163 million instead of \$519 million.

One of the things this \$163 million does not take into account is the reduction in congestion. However, sold permits would have been more efficient in terms of decreasing the costs of congestion because those willing to pay \$6,700 or more for a congestion relief are those with the highest value of time irrespective of vehicle choice. As Parry (2002) finds, the biggest efficiency gains from congestion pricing come from separating high value and low value users into fast and slow lanes, not necessarily from encouraging low value users to use public transit or travel during off-peak times.

Another reason to give incentives to hybrid cars is to encourage their early adoption. However by 2006, hybrids were already growing in popularity and only 18 percent of the sample of used cars for sale had a Clean Air Sticker. In a memo opposing the AB 2628, the Sacramento Council of Governments (SACOG) stated that AB 2628 would “not significantly shift demand or induce car makers to expedite their transition to hybrid technology”.¹³ It is also of dubious value to give a car purchased in 2000 a sticker to encourage its purchase in 2006. The state of California could have had an equal amount

¹¹ 0.4 grams per mile of NO_x was the standard for 2000 model year cars. The median model year for a car with a Clean Air sticker is 2005 which falls under a stricter standard.

¹² The average passenger car is driven approximately 12,000 miles per year, hybrid cars with a Clean Air Sticker in the sample are driven 19,000 miles per year.

¹³ <http://www.sacog.org/calendar/2004/july04/leg/3AB2628.pdf>

of CO₂, NO_x and comparable congestion reductions for approximate 32% of the cost by selling permits to any vehicle rather than giving them away to hybrid cars.

CONCLUSION

This paper uses a dataset collected from internet and print sources to estimate the value of a Clean Air sticker which allows a hybrid car to drive on HOV lanes with a single passenger. A hedonic model of car price is used resulting in an estimate of approximately \$3,600 per year for the Clean Air sticker. The estimate of approximately \$3,600 per year is robust across specifications and is in accordance with previous studies on the value of travel time savings. It is also likely an underestimate of the willingness-to-pay for HOV lane privileges. The restriction that the car must be one of three types of hybrids, a used Toyota Prius, Honda Civic or Honda Insight produced before 2007, limits the potential market for these privileges.

Initially the value of the sticker rose as it became clear that the DMV was reaching the maximum number of stickers. As the sticker is set to expire on January 1, 2011, the price of the sticker has steadily fallen with time. At its peak, the Clean Air sticker was estimated to have been worth \$6,100. While the state of California gave these stickers out for only \$8 each, they clearly had value.

REFERENCES

- Barrett, J. (2009) Unpublished PhD Dissertation, Department of Agricultural and Resource Economics, University of California, Davis.
- Brownstone, D. and K. Small. (2005) Valuing time and reliability: assessing the evidence from road pricing demonstrations. *Transportation Research Part A*, Vol. 39, Pgs. 279-293.
- Consumer Reports. (2008) The natural-gas alternative: the pros & cons of buying a CNG-powered Honda Civic. http://www.consumerreports.org/cro/cars/new-cars/news/2006/the-pros-cons-of-buying-a-cng-powered-honda-civic/overview/0609_how-to-jump-start-a-car_ov.htm, <Accessed January 18, 2009>.
- Bay Area Toll Authority. (2009) Tolls and Traffic, <http://bata.mtc.ca.gov/tolls/schedule.htm>, <Accessed January 18, 2009>.
- Boriboonsomsin, K. and M. Barth. (2008) Impacts of freeway high-occupancy vehicle lane configuration on vehicle emissions. *Transportation Research Part D*, Vol. 13, Pgs. 112-125.
- Breiland, C., L. Chu and H. Benouar. (2006) Operational effect of allowing single

- occupant hybrid vehicles into high occupancy vehicle lanes. 2006 TRB Annual Meeting, paper #06-2813.
- Brownstone, D., L. Chu, T. Golob, K. Nesamani and W. Recker. (2007) Evaluation of incorporating hybrid vehicle use of HOV lanes, Draft Final Report for PATH to 5315.
- Brownstone, D. and K. Small. (2005) Valuing time and reliability: assessing the evidence from road pricing demonstrations, *Transportation Research Part A*, Vol. 39, Pgs. 279-293.
- Brownstone, D., A. Ghosh, T. Golob, C. Kazimi, D. Amelsfort. (2003) Drivers' willingness-to-pay to reduce travel time: evidence from the San Diego 1-15 congestion pricing project, *Transportation Research Part A*, Vol 37, Pgs. 373-387.
- Covarrubias, A. (2006) In carpool lanes, hybrids find cold shoulders, *The Los Angeles Times*, April 10.
- Golden Gate Bridge. (2009) Tolls and Traffic Operations, http://goldengatebridge.org/tolls_traffic/toll_rates_carpools.php, <Accessed January 18, 2009>.
- Griliches, Z. (1971) Hedonic price indexes of automobiles: an econometric analysis of quality change, in Griliches, Z. (ed.), *Price Indexes and Quality Change*, Harvard University Press, Cambridge.
- Honda Cars, (2009) <http://automobiles.honda.com>, <Accessed January 19, 2009>.
- Kwon, J. and P. Varaiya. (2008) Effectiveness of California's High Occupancy Vehicle (HOV) system, *Transportation Research Part C*, Vol. 16, Pgs. 98-115.
- Legislative Analyst's Office, (2000) HOV Lanes in California: Are they achieving their goals?, http://www.lao.ca.gov/2000/010700_hov/010700_hov_lanes.html, <Accessed December 15, 2008>.
- National Public Radio. (2007) Access to Calif. HOV lane puts premium on hybrids. April 17, <http://www.npr.org/templates/story/story.php?storyId=9626745>, <Accessed January 20, 2009>.
- Palmquist, R. (2003) Property value models, in Maler and Vincent (eds) *Handbook of Environmental Economics*, Vol. 2.
- Parry, I.W.H. (2002) Comparing the efficiency of alternative policies for reducing traffic congestion, *Journal of Public Economics*, Vol. 85, Pgs. 333-362.

- Pavley, F. (2004) Assembly Bill No. 2628, California State Senate, <http://www.leginfo.ca.gov/pub/03-04/bill/asm/ab_2601-2650/ab_2628_bill_20040923_chaptered.pdf> Accessed May 5, 2009.
- Pavley, F. (2004) Assembly Joint Resolution No. 74, California State Senate, <http://www.leginfo.ca.gov/pub/03-04/bill/asm/ab_0051-0100/ajr_74_bill_20040708_chaptered.pdf> Accessed May 5, 2009.
- RIDES Associates. (2005) Commute Profile 2005, Prepared for the Metropolitan Transportation Commission's Regional Rideshare Program.
- Rosen, S. (1974) Hedonic prices and implicit markets: product differentiation in pure competition, *Journal of Political Economy*, Vol. 82, Pgs. 34-55.
- San Joaquin Valley Unified Air Pollution Control District (2008) Update to Rule 2201 Best Available Control Technology (BACT) Cost Effectiveness Thresholds, Final Staff Report. May 18.
- Small, K. (1992) *Urban Transportation Economics*, Fundamentals of Pure and Applied Economics Series, Vol. 51, Harwood Academic Publishers, New York.
- Smith, V. and J. Huang. (1993) Hedonic models and air pollution: twenty-five years and counting, *Environmental and Resource Economics*, Vol. 3, Pgs. 381-394.
- Steinmetz, S. and D. Brownstone. (2005) Estimating commuters' "value of time" with noisy data: a multiple imputation approach, *Transportation Research Part B*, Vol. 39, Pgs. 865-889.
- Tierney, J. (2005) The road to hell is clogged with righteous hybrids, *The New York Times*, August 2005.