CHAPTER 4 RESEARCH ANALYSIS

The analyzing methods of the research, in this chapter, are divided into three parts. The first part is described about Bass model and its parameter. The second part uses mathematics and timeline to analyze the number of registered vehicles in the past. The last part is to analyze the policies related to HEV and eco car.

4.1 Fundamental Analysis

In this part, statistical data and timeline will be used to analyze the diffusions of HEV and eco car. Time line will show the situation related to both types of vehicles such as related policies/campaigns, annual automobile exhibitions, new car debuts and retail fuel prices from PTT website. (Figure 4.1)

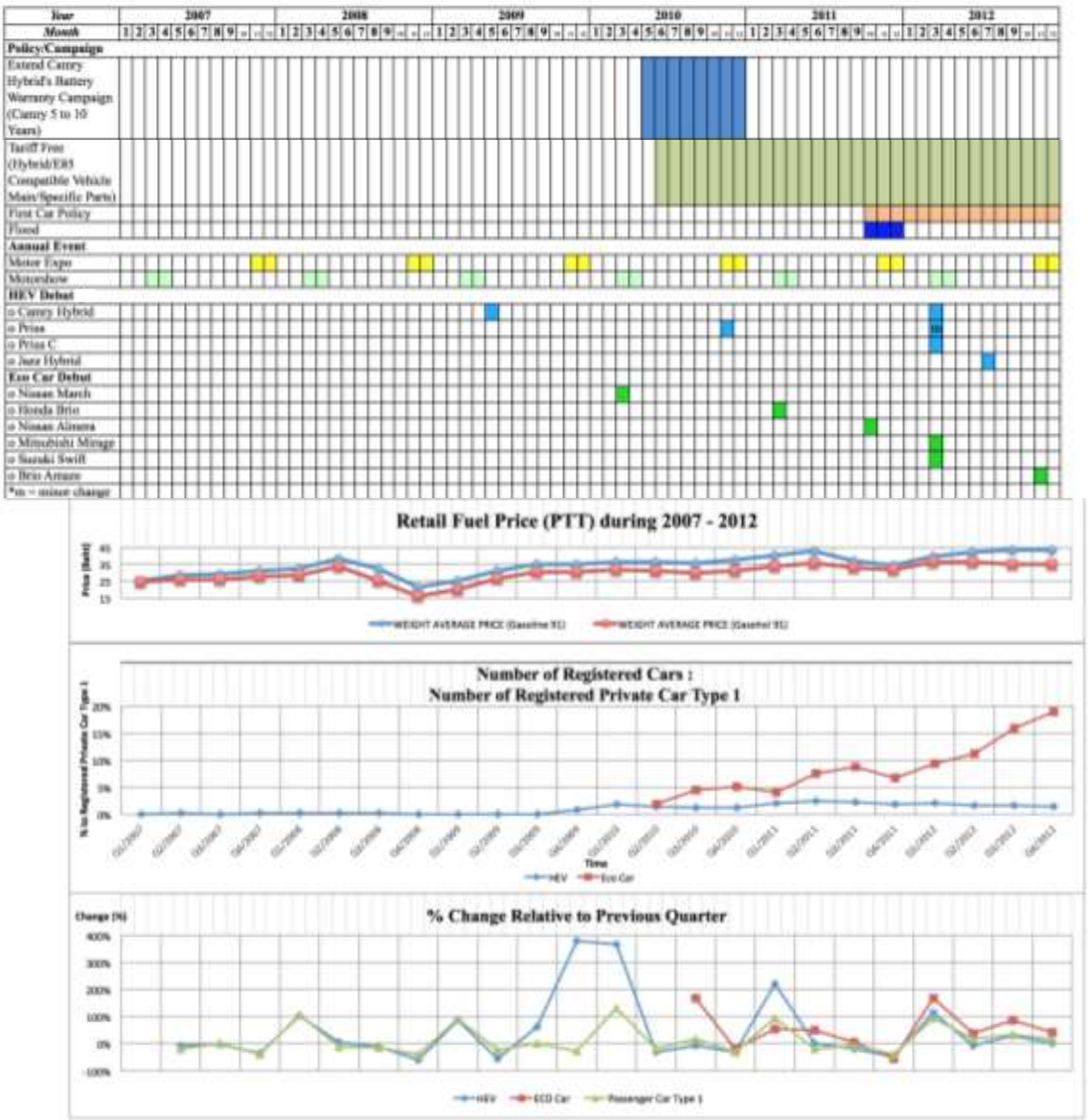

Figure 4.1 Timeline of HEV and Eco Car

The statistical data in this part will be analyzed with three aspects.

1) Percent of new registered vehicle in each quarter
2) Percent of accumulated registered vehicle in each quarter
3) Percent change of the number of new registered vehicles

4.1.1 Percent of New Registered Vehicles in Each Quarter

In this part, these two following formula will be used to make the graph (Figure 4.2) and data (Table 4.1) for analysis. The percent of new registered vehicles in each quarter is good way to analyze change in adoption because it excludes data from seasonal effect because vehicle sales have high and low season.

$$\%\ new\ registered\ HEVs = \frac{The\ number\ of\ new\ registered\ HEVs}{The\ number of\ new\ registered\ passenger\ cars\ (type\ 1)}$$

$$\%\ new\ registered\ eco\ cars = \frac{The\ number\ of\ new\ registered\ eco\ cars}{The\ number of\ new\ registered\ passenger\ cars\ (type\ 1)}$$

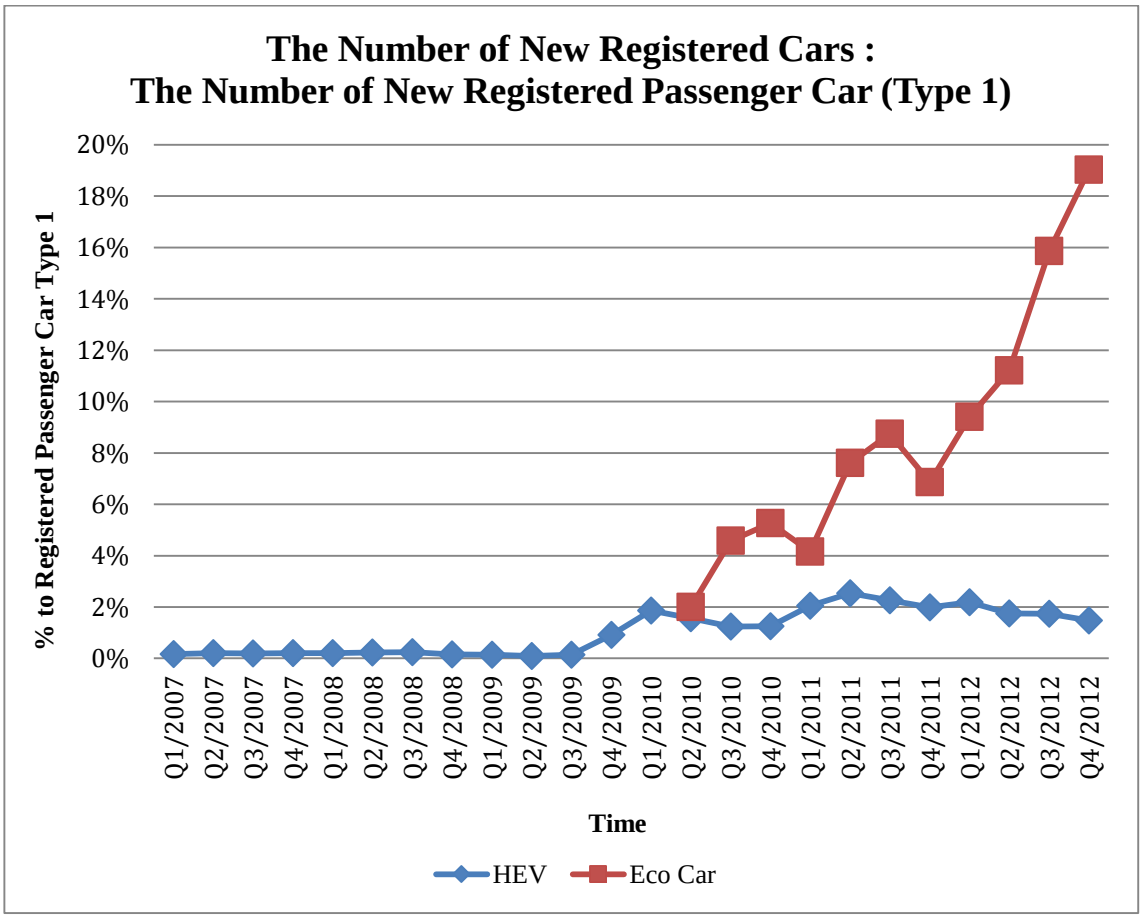

Figure 4.2 Ratios of New Registered Vehicles

Table 4.1 The Number of New Registered HEVs, Eco Cars and Private Cars (Type 1) from January 1, 2007 – December 31, 2012 at the End of each Period (3 months)

	HEV	ECO Car	Registered Private Car Type 1	% HEV Registered	% Eco Car Registered
Q1/2007	165		97,674	0.17%	
Q2/2007	156		78,352	0.20%	
Q3/2007	152		79,856	0.19%	
Q4/2007	102		49,786	0.20%	
Q1/2008	208		104,074	0.20%	
Q2/2008	218		93,076	0.23%	
Q3/2008	193		81,202	0.24%	
Q4/2008	78		50,938	0.15%	
Q1/2009	146		98,066	0.15%	
Q2/2009	68		75,725	0.09%	
Q3/2009	110		77,736	0.14%	
Q4/2009	527		57,623	0.91%	
Q1/2010	2,468		132,590	1.86%	
Q2/2010	1,704	2,185	109,230	1.56%	2.00%
Q3/2010	1,592	5,895	128,542	1.24%	4.59%
Q4/2010	1,132	4,761	90,378	1.25%	5.27%
Q1/2011	3,640	7,379	177,585	2.05%	4.16%
Q2/2011	3,697	11,123	146,137	2.53%	7.61%
Q3/2011	3,074	11,922	136,270	2.26%	8.75%
Q4/2011	1,610	5,565	81,034	1.99%	6.87%
Q1/2012	3,485	14,977	159,272	2.19%	9.40%
Q2/2012	3,290	20,992	187,268	1.76%	11.21%
Q3/2012	4,337	39,504	248,990	1.74%	15.87%
Q4/2012	4,423	56,831	298,653	1.48%	19.03%
Q1/2013	-	58,229	306,617	-	18.99%

Source: Department of Land Transport (2013)

In case of HEV, the result shows that the ratio of new registered HEVs to new registered passenger cars (type 1) during the same period of time fluctuated within a small range for the first two years (Average Q1/2007 – Q3/2008 : 0.20%) and then the ratio went downwards (Q4/2008 : 0.15%). This might be the result of oil price that had

fallen down rapidly since Q3/2008 and reached the lowest level on December 27, 2008. After that the ratio was still at very low level until Camry hybrid was introduced. The ratio has grown rapidly during Q4/2009 – Q1/2010 (0.91% and 1.86 % respectively) and the ratio was slightly decreased over the past two years (except Q1/2012 which was the period that Prius with minor change, Prius C and all new Camry Hybrid were introduced).

In case of eco car, the result shows that the ratio of new registered eco cars to new registered passenger cars (type 1) during the same period of time has increased incessantly except Q1/2011 and Q4/2011. The ratio in Q1/2011 fell a bit. The news that Honda will introduce Honda Brio at Motorshow 2011 might have some impacts on potential adopters and made them postpone buying.

In case of Q4/2011, due to the fact that Bangkok people suffered from floods in October – November, 2011, the ratio of new registered passenger cars (type 1) in Bangkok to which in whole kingdom had fallen down during that period of time (Table 4.2). Consequently, the ratio of new registered eco cars to new registered passenger cars (type 1) in Q4/2011 reduced from 8.75% to 6.87%. This reflects that majority of eco car adopters are the people who live and/or work in Bangkok.

Table 4.2 Ratio of New Registered Passenger Car (Type 1) in Bangkok to which in Whole Kingdom

	Bangkok	**Regional**
January – September, 2011	52.90 – 55.78%	44.22 – 47.10%
October, 2011	46.13%	53.87%
November, 2011	42.99%	57.01%
December, 2011	53.15%	46.85%

Source: Department of Land Transport (2013)

In 2012, the ratio increased faster. This might be the results of three factors.

1) There were many models of eco cars introduced to market additional to Nissan March and Honda Brio. Nissan Almera, Mitsubishi Mirage, Suzuki Swift and Honda Brio Amaze were put up for sale.

2) First car scheme refunded about 53,000 – 79,000 excise tax for eco car. This made some people, who had a plan to buy eco car after 2012, changed their mind to buy a car earlier.

3) The tax refund also made eco car more attractive and affordable. Consequently, some people adopted this type of vehicle although prior to first car scheme they were not potential adopters.

4.1.2 Percent of Accumulated Registered Vehicles in Each Quarter

In this part, this two following will be used to make the graph (Figure 4.3) and data (Table 4.4) for analysis. The percent of accumulated registered vehicles in each quarter is the good index to show the ratio low emission vehicle on the road relative to others.

Note: This research does not take EV which is one type of LEV into consideration.

$$\%\ accumulated\ registered\ HEVs = \frac{The\ number\ of\ new\ registered\ HEVs}{The\ number of\ new\ registered\ passenger\ cars\ (type\ 1)}$$

$$\%\ accumulated\ registered\ eco\ cars = \frac{The\ number\ of\ new\ registered\ eco\ cars}{The\ number of\ new\ registered\ passenger\ cars\ (type\ 1)}$$

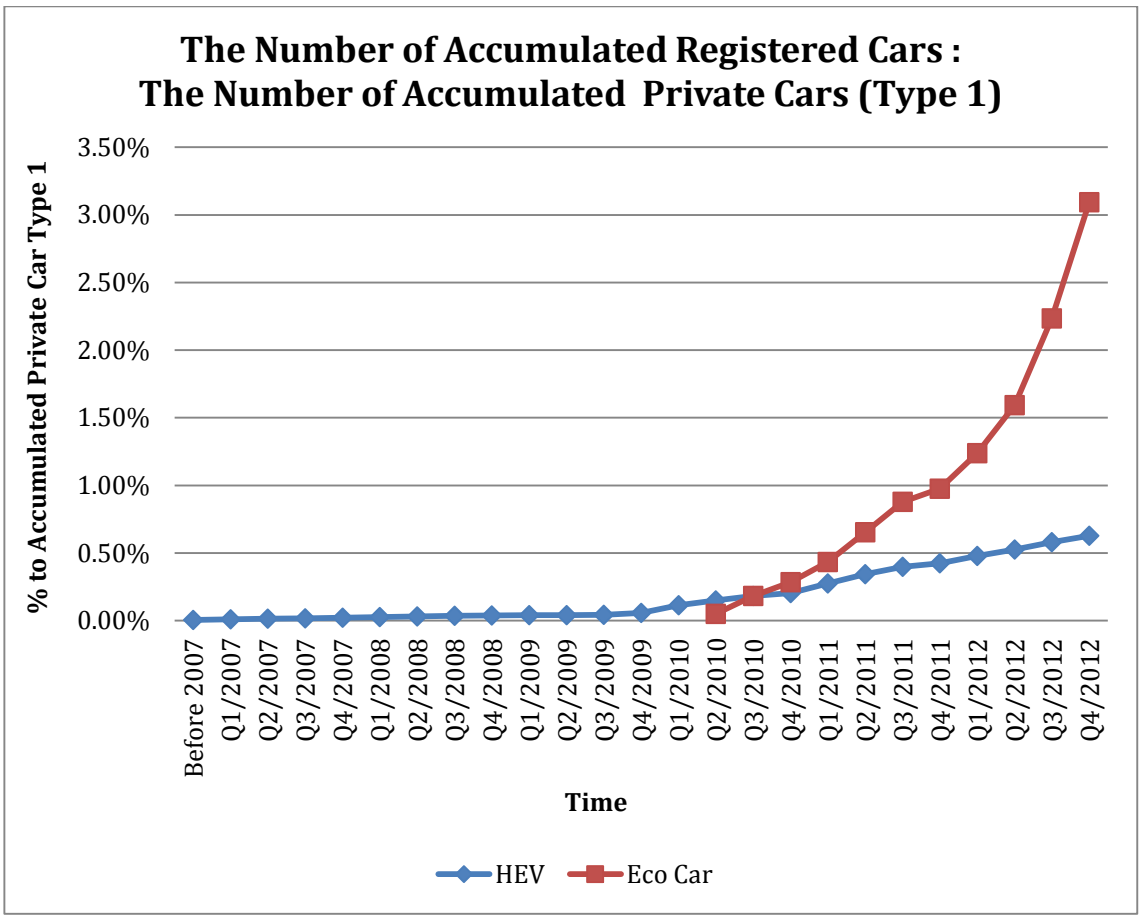

Figure 4.3 Ratios of Accumulated Registered Vehicles

The ratio shows that the proportion of accumulated HEV and eco cars on the road relative to other passenger type 1 vehicle gradually increases, but eco car ratio grows with higher rate. This means there are more people buy LEV instead of normal car. The more proportions of HEVs and eco cars on the road are, the less fuels are burnt. (Less CO_2 and other GHG emissions) (Table 4.3 and Figure 4.4)

Table 4.3 Fuel economy and Emission for Vehicle Model 2012

Vehicle	Engine Size (liters)	EPA City mileage (mpg)	EPA Highway mileage (mpg)	EPA Combined mileage (mpg)	Tailpipe emissions (g/km)	Annual Petroleum Use (liters)
Eco Car Standard	1.3	20 km/l			120.0	1,207.0
Toyota Yaris	1.5	30 mpg-US (12.8 km/l)	35 mpg-US (14.9 km/l)	32 mpg-US (13.6 km/l)	172.7	1,637.7
Honda Fit (Jazz)	1.5	27 mpg-US (11.5 km/l)	33 mpg-US (14.0 km/l)	30 mpg-US (13.6 km/l)	183.9	1,749.0
Prius c	1.5	53 mpg-US (22.5 km/l)	46 mpg-US (19.6 km/l)	50 mpg-US (21.3 km/l)	110.6	1,049.4
Honda Civic	1.8	28 mpg-US (11.9 km/l)	39 mpg-US (16.6 km/l)	32 mpg-US (13.6 km/l)	172.7	1,637.7
Toyota Corolla	1.8	26 mpg-US (11.1 km/l)	34 mpg-US (14.5 km/l)	29 mpg-US (12.3 km/l)	190.1	1,812.6
Prius 3rd gen	1.8	51 mpg-US (21.7 km/l)	48 mpg-US (20.4 km/l)	50 mpg-US (21.3 km/l)	110.6	1,049.4
Honda Accord	2.4	23 mpg-US (9.8 km/l)	34 mpg-US (14.5 km/l)	27 mpg-US (11.5 km/l)	204.4	1,939.8
Toyota Camry	2.4	25 mpg-US (10.6 km/l)	35 mpg-US (14.9 km/l)	28 mpg-US (11.9 km/l)	197.0	1,876.2
Toyota Camry Hybrid LE	2.4	43 mpg-US (18.3 km/l)	39 mpg-US (16.6 km/l)	41 mpg-US (17.4 km/l)	134.8	1,272.0
Toyota Camry Hybrid XLE	2.4	40 mpg-US (17.0 km/l)	38 mpg-US (16.2 km/l)	40 mpg-US (17.0 km/l)	137.9	1,303.8

**Based on 45% highway, 55% city driving, 15,000 annual miles,*
1 Barrel = 158.987294928 liters,
1 mile per gallon = 0.425143707 kilometers per liter,
1 mile = 1.60934 km.

Source: U.S. Department of Energy (2012)

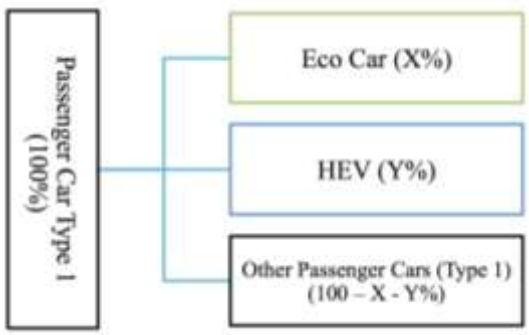

Figure 4.4 Buying Decision

Table 4.4 The Number of Accumulated Registered HEVs, Eco Cars and Private Cars Type 1 from October 1, 2006 – December 31, 2012 at the End of each Period

	Accumulated Registered HEV	Accumulated Registered Eco	Accumulated Registered Private Car Type 1	Ratio Acc. HEV	Ratio Acc. ECO
Before 2007	168		3,312,941	0.01%	
Q1/2007	333		3,381,736	0.01%	
Q2/2007	489		3,451,019	0.01%	
Q3/2007	641		3,521,147	0.02%	
Q4/2007	743		3,560,222	0.02%	
Q1/2008	951		3,644,411	0.03%	
Q2/2008	1,169		3,703,322	0.03%	
Q3/2008	1,362		3,768,927	0.04%	
Q4/2008	1,440		3,809,082	0.04%	
Q1/2009	1,586		3,893,834	0.04%	
Q2/2009	1,654		3,959,611	0.04%	
Q3/2009	1,764		4,029,108	0.04%	
Q4/2009	2,291		4,078,547	0.06%	
Q1/2010	4,759		4,199,110	0.11%	
Q2/2010	6,463	2,185	4,299,614	0.15%	0.05%
Q3/2010	8,055	8,080	4,416,728	0.18%	0.18%
Q4/2010	9,187	12,841	4,496,828	0.20%	0.29%
Q1/2011	12,827	20,220	4,662,483	0.28%	0.43%
Q2/2011	16,524	31,343	4,800,796	0.34%	0.65%
Q3/2011	19,598	43,265	4,928,192	0.40%	0.88%
Q4/2011	21,208	48,830	5,001,442	0.42%	0.98%
Q1/2012	24,693	63,807	5,148,368	0.48%	1.24%
Q2/2012	27,983	84,799	5,326,095	0.53%	1.59%
Q3/2012	32,320	124,303	5,565,157	0.58%	2.23%
Q4/2012	36,743	181,134	5,856,454	0.63%	3.09%
Q1/2013	-	239,363	6,153,912	-	3.89%

**The numbers of accumulated registered HEV and eco car are summation of the number of registered cars in that period and the number of accumulated registered cars in previous period.*

Source: Department of Land Transport (2013)

4.1.3 Percent Change of the Number of New Registered Vehicles

In this part, these two following formula will be used to make the graph (Figure 4.5) and data (Table 4.5) for analysis. The percent change of the number of new registered vehicles relative to previous quarter shows pattern of change.

%△ new registered HEVs =

$$\frac{The\ number\ of\ new\ registered\ HEVs(t) - The\ number\ of\ new\ registered\ HEVs(t-1)}{The\ number\ of\ new\ registered\ HEVs(t-1)}$$

%△ new registered eco cars =

$$\frac{The\ number\ of\ new\ registered\ eco\ cars(t) - The\ number\ of\ new\ registered\ eco\ cars(t-1)}{The\ number\ of\ new\ registered\ eco\ cars(t)}$$

%△ new registered passenger cars (Type 1) =

$$\frac{The\ number\ of\ new\ registered\ passenger\ cars\ type\ 1(t) - The\ number\ of\ new\ registered\ passenger\ cars\ type\ 1(t-1)}{The\ number\ of\ new\ registered\ passenger\ cars\ type\ 1(t)}$$

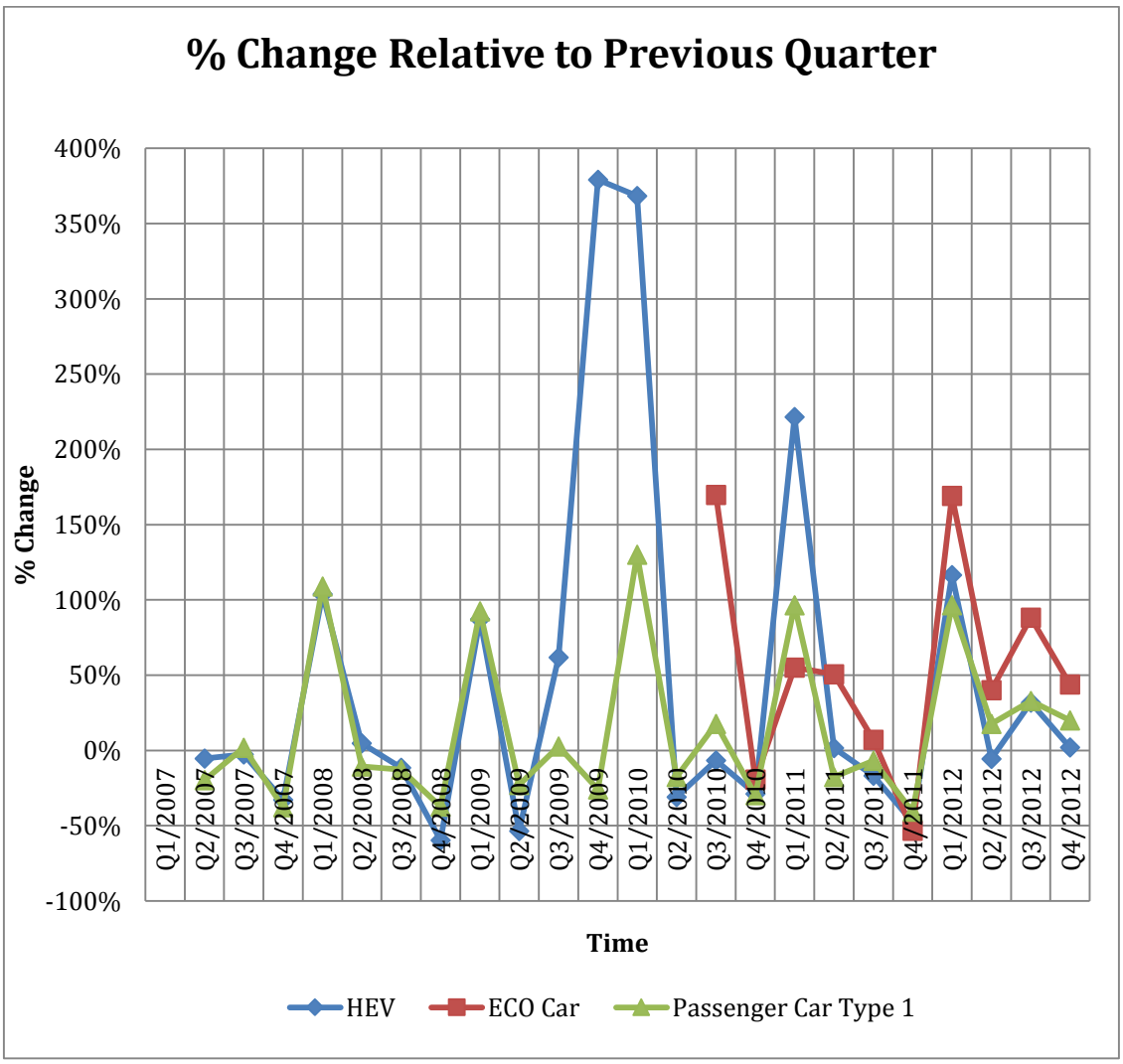

Figure 4.5 % Change Relative to Previous Quarter

Table 4.5 Percent Change of the Number of New Registered HEVs, Eco Cars and Passenger Cars Type 1 from October 1, 2006 – December 31, 2012 at the End of Each Quarter

Time	HEV (1)	ECO Car (2)	Registered Passenger Car Type 1 (3)	△(1)	△(2)	△(3)
Q1/2007	165		97,674			
Q2/2007	156		78,352	-5.45%		-19.78%
Q3/2007	152		79,856	-2.56%		1.92%
Q4/2007	102		49,786	-32.89%		-37.66%
Q1/2008	208		104,074	103.92%		109.04%
Q2/2008	218		93,076	4.81%		-10.57%
Q3/2008	193		81,202	-11.47%		-12.76%
Q4/2008	78		50,938	-59.59%		-37.27%
Q1/2009	146		98,066	87.18%		92.52%
Q2/2009	68		75,725	-53.42%		-22.78%
Q3/2009	110		77,736	61.76%		2.66%
Q4/2009	527		57,623	379.09%		-25.87%
Q1/2010	2,468		132,590	368.31%		130.10%
Q2/2010	1,704	2,185	109,230	-30.96%		-17.62%
Q3/2010	1,592	5,895	128,542	-6.57%	169.79%	17.68%
Q4/2010	1,132	4,761	90,378	-28.89%	-19.24%	-29.69%
Q1/2011	3,640	7,379	177,585	221.55%	54.99%	96.49%
Q2/2011	3,697	11,123	146,137	1.57%	50.74%	-17.71%
Q3/2011	3,074	11,922	136,270	-16.85%	7.18%	-6.75%
Q4/2011	1,610	5,565	81,034	-47.63%	-53.32%	-40.53%
Q1/2012	3,485	14,977	159,272	116.46%	169.13%	96.55%
Q2/2012	3,290	20,992	187,268	-5.60%	40.16%	17.58%
Q3/2012	4,337	39,504	248,990	31.82%	88.19%	32.96%
Q4/2012	4,423	56,831	298,653	1.98%	43.86%	19.95%
Q1/2013	-	58,229	306,617	-	2.46%	2.67%

Source: Department of Land Transport (2013)

Normally, %△ new registered HEV and %△ new registered eco car should conform to %△ new registered passenger car (Type 1). However, there are some periods that they

are disparate.

In Q4/2009, %△ new registered HEV was 379.09% while %△ new registered passenger car (Type 1) was -25.87%. This is the consequence of placing Prius Generation 3 on sales. Toyota was officially debuted this model at the January 2009 North American International Auto Show and then ranked the most efficient car powered by liquid fuel available in the U.S. in 2009. When it was debuted in Thailand, it was rapidly accepted by first adopters. Moreover, the oil price which had increased since Q3/2009 supports Prius as fuel economy vehicle.

In Q2/2012, %△ new registered HEV was -5.6% while %△ new registered passenger car (Type 1) was 17.58%. The reason is that no HEV model to *"First Car Scheme"* at that period. However, the %△ new registered HEV in Q1/2012 and Q3/2012 increased because there were 3 HEV models (Toyota Prius with minor change, All new Toyota Camry Hybrid and Toyota Prius C) put on sale in Q1/2012 and Jazz Hybrid which conform to the policy put on sales in Q3/2012.

Summarily, all the methods show that there are 3 factors related to diffusion patterns of both types of vehicles, namely new car launch, oil price change and government incentives.

4.2 Bass Model Parameter

The first step is to use *Data Analysis* in *Microsoft Excel* to find the Pearson correlation coefficient between N(t) and n(t) of both cases. The results in both cases show that there are very high degree of positive relationships between total number of adopters of the innovation by time t and the number of adopter at particular time t (Table 4.6).

Note: Eco car was classified into 2 groups. The first group uses only data before the first car scheme (Q2/2010 – Q3/2011). The second group uses all data (Q2/2010 – Q1/2013).

Table 4.6 The Pearson Correlation Coefficient between N(t) and n(t)

HEV	Eco Car (Before First Car Scheme)	Eco Car
0.864956535889213	0.930358805738341	0.952192539161885

After using *Data Analysis Add-in* in *Microsoft Excel* with data in Appendix C (HEV) and Appendix D (Eco Car), the results are fit curves (Figure 4.6 and 4.7) and the coefficients of equation (7) shown in table 4.7.

Note: Eco car data have to change the time periods from monthly into quarterly before analyzing by regression.

$$n(t) = \alpha_1 + \alpha_2 N(t) + \alpha_3 N^2(t)$$

Each equation is the function of p, q and m

$\alpha_1 = pm$

$\alpha_2 = q - p$

$$\alpha_3 = -\frac{q}{m}$$

Table 4.7 Coefficients Obtained from Data Analysis

Coefficient	HEV	Eco Car (Before First Car Scheme)	Eco Car
α_1	141.3937608	3,038.55554327671	697.5966337
α_2	0.246304052	0.430030997286789	0.410131029
α_3	-0.00000396532	-0.000004351487	-0.000000361138
Adjusted R^2	0.766364025040142	0.803342134681265	0.889454238038333
Standard Error	766.9612441	1665.43778558364	6,713.481674

The α_1 reflects the number of first adopters (innovators) that time period 1. The result shows that in period 1 eco car had more innovators than HEV no matter which data being used. Due to the fact that eco car is only downsizing vehicle with additional standards while HEV is more expensive vehicle with advance technology, eco car has more relative advantage, compatibility but less complexity.

The α_2 reflects the difference between q and p. The result shows that both HEVs and eco cars are mainly influenced by imitation effect. Anyways, the difference *p* and *q* in eco cars adoption is greater than which in HEVs. This makes eco car has greater rate of adoption than HEVs.

The α_3 does not have direct meaning.

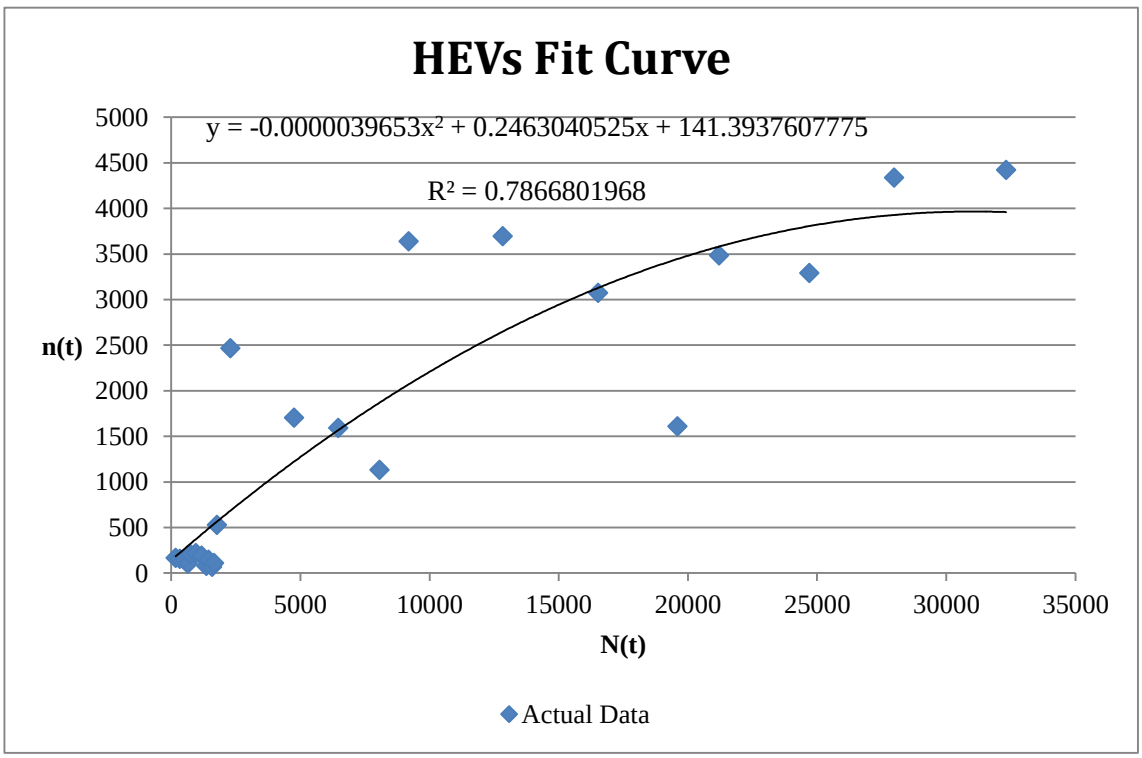

Figure 4.6 HEVs Fit Curve

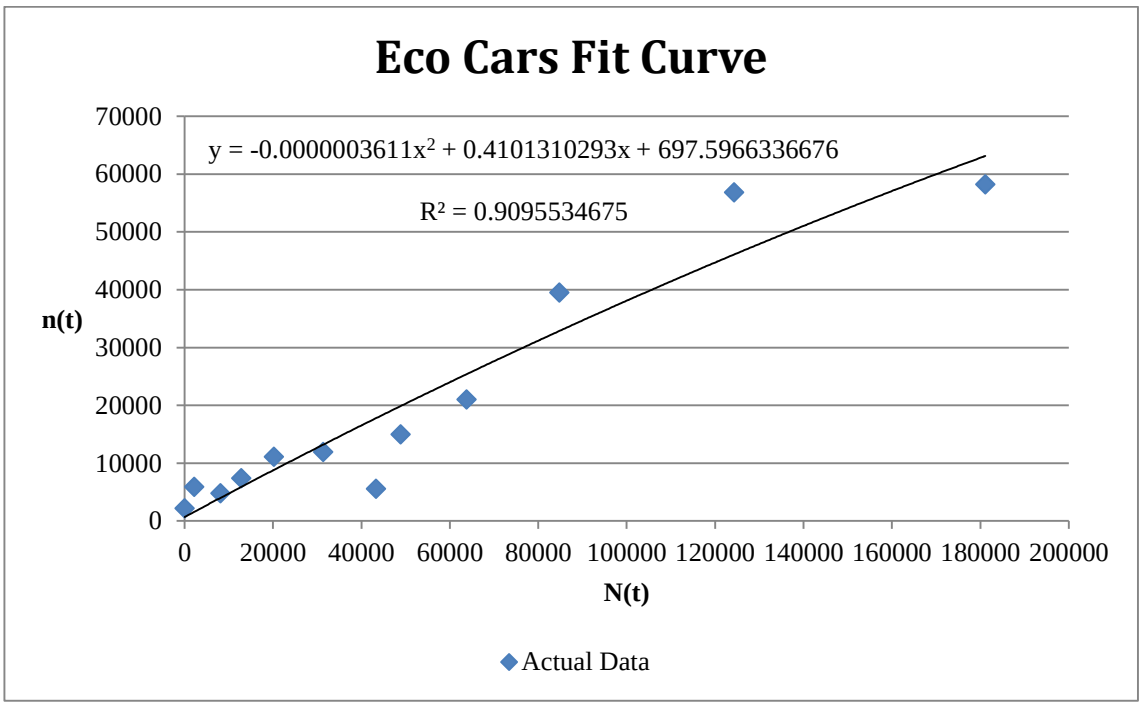

Figure 4.7 Eco Cars Fit Curve

4.2.1 Bass Model Coefficients for HEV

Substitute $\alpha 1$, $\alpha 2$, $\alpha 3$ in equation (6) with data obtained from regression.

$$N(t) = 141.3937608 + 0.246304052\ N(t) - 0.00000396532\ N^2(t)$$

Use equation (10), (12) and (16) to solve for parameter p, q, m

$$p = \frac{-(0.246304052) \pm \sqrt{(0.246304052)^2 - 4(141.3937608)(-0.00000396532)}}{2}$$

$$q = \frac{(0.246304052) \pm \sqrt{(0.246304052)^2 - 4(141.3937608)(-0.00000396532)}}{2}$$

$$m = \frac{-(0.246304052) \pm \sqrt{(0.246304052)^2 - 4(141.3937608)(-0.00000396532)}}{2(-0.00000396532)}$$

Then, solve the equation to find 2 roots of each parameter.

Table 4.8 Roots obtained from quadratic formula (HEV)

Parameter	Positive Root	Negative Root
p	0.00225568	-0.2485597
q	0.248559732	-0.0022557
m	62,683.43764	-568.85224

4.2.2 Bass Model Coefficients for Eco Car before First Car Scheme

Substitute $\alpha 1$, $\alpha 2$, $\alpha 3$ in equation (6) with data obtained from regression.

$$N(t) = 3038.55554328 + 0.430030997\, N(t) - 0.00000435148667\, N^2(t)$$

Use equation (10), (12) and (16) to solve for parameter p, q, m

$$p = \frac{-(0.430030997) \pm \sqrt{(0.430030997)^2 - 4(3038.55554328)(-0.00000435148667)}}{2}$$

$$q = \frac{(0.430030997) \pm \sqrt{(0.430030997)^2 - 4(3038.55554328)(-0.00000435148667)}}{2}$$

$$m = \frac{-(0.430030997) \pm \sqrt{(0.430030997)^2 - 4(3038.55554328)(-0.00000435148667)}}{2(-0.00000435148667)}$$

Then, solve the equation to find 2 roots of each parameter.

Table 4.9 Roots Obtained from Quadratic Formula (Eco car (before First Car Scheme))

Parameter	Positive Root	Negative Root
p	0.030038929	-0.440169958
q	0.440169958	-0.030038929
m	101153.9255	-6903.141591

4.2.3 Bass Model Coefficients for Eco Car

Substitute $\alpha 1$, $\alpha 2$, $\alpha 3$ in equation (6) with data obtained from regression.

$$N(t) = 697.5966337 + 0.410131029\, N(t) - 0.000000361138\, N^2(t)$$

Use equation (10), (12) and (16) to solve for parameter p, q, m

$$p = \frac{-(0.410131029) \pm \sqrt{(0.410131029)^2 - 4(697.5966337)(-0.000000361138)}}{2}$$

$$q = \frac{(0.410131029) \pm \sqrt{(0.410131029)^2 - 4(697.5966337)(-0.000000361138)}}{2}$$

$$m = \frac{-(0.410131029) \pm \sqrt{(0.410131029)^2 - 4(697.5966337)(-0.000000361138)}}{2(-0.0000001183804456)}$$

Then, solve the equation to find 2 roots of each parameter.

Table 4.10 Roots obtained from quadratic formula (Eco car)

Parameter	Positive Root	Negative Root
p	0.000613347	-0.410744376
q	0.410744376	-0.000613347
m	1137360.99	-1698.371723

However, "p" and "q" are measures of likelihood of innovation adoption by internal influence and external influence respectively, their value should be between 0 (0% chance) and 1 (100%), and "m" is the saturate point so it should be positive number. These constraints make the roots of quadratic function which are negative value become invalid.

Table 4.11 Valid parameter for both cases

Parameter	HEV	Eco Car (Before First Car Scheme)	Eco Car
p	0.00225568	0.030038929	0.000613347
q	0.248559732	0.440169958	0.410744376
m	62,683.44	101,153.93	1,137,360.99

Anyways, the parameters of eco car before first car scheme are not suitable to predict because its projection could not be used with data after the policy was enforced As shown in figure 4.8, (a), the fit curve derived from data before policy, have the peak for sales of eco car occurred between Q1/2011 – Q1/2012 and then its trend went downwards. However, after the policy was implemented at September 15, 2011, the eco car sales increase dramatically. This implies that the government incentives had some impacts on the parameters of Bass model and changed the pattern of diffusion. The fit curve (b) derived from data between Q2/2010 – Q1/2013 becomes more proper for fitting the data after Q1/2012. Thus, the parameters of Bass model for eco car before first car scheme will not be used in this analysis anymore.

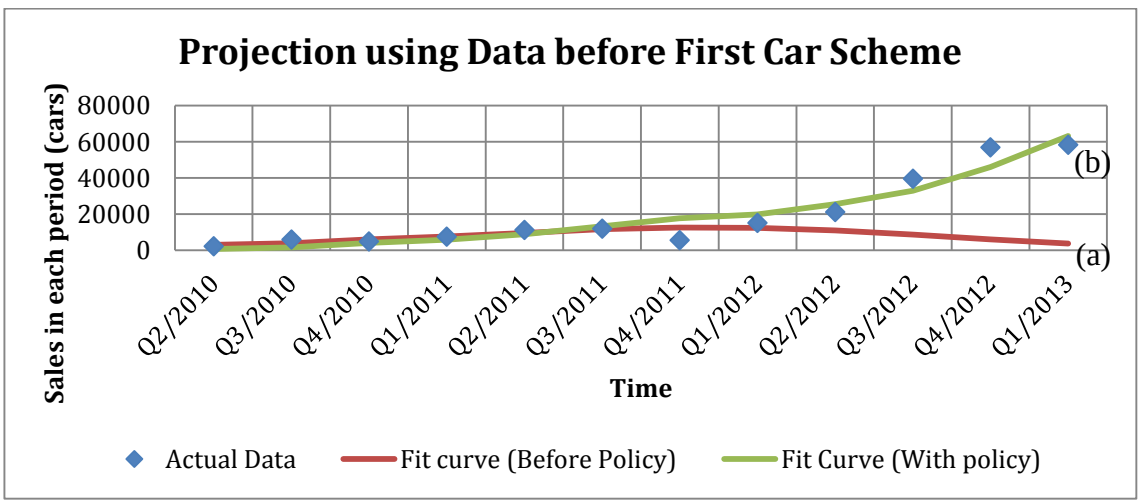

Figure 4.8 Projection using Data before First Car Scheme

S-curves obtained from HEV and eco car reflect that the diffusions of HEV and eco car are the result of imitation effect (Figure 4.9 and 4.10) whereas *m* reflects the total number of potential customers who will eventually use the durable product which once are adopted and not repurchased for many years. The saturation point without continuous repeat purchasing of eco car (~1,137,361) is 18 times greater than which of HEV (~62,683).

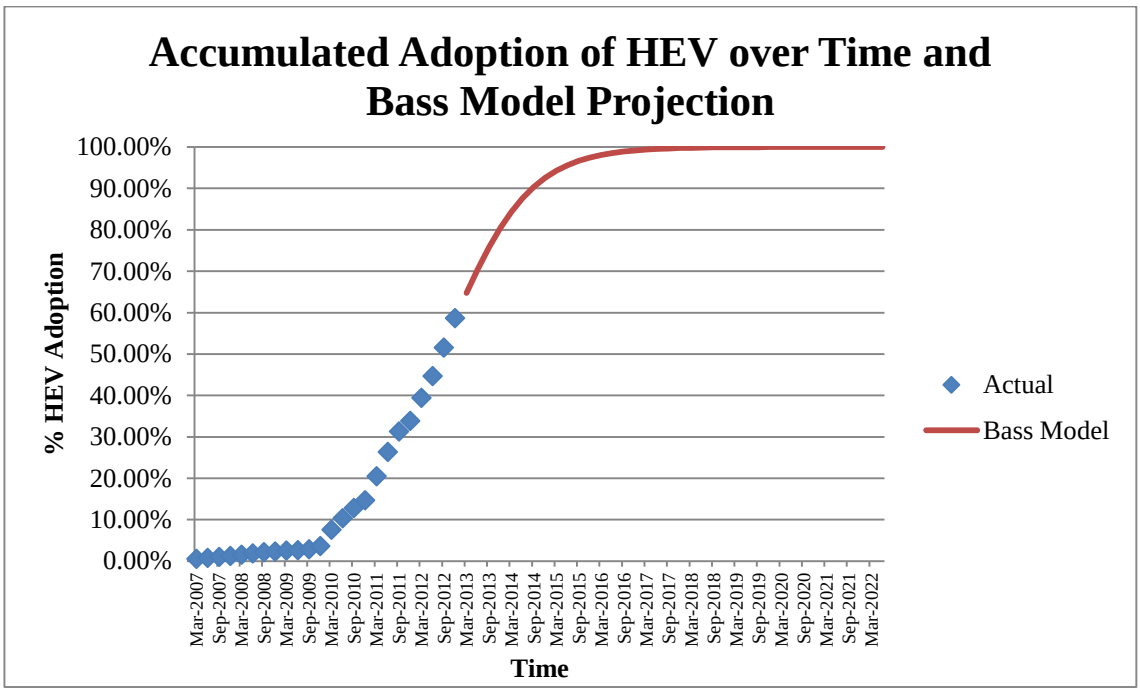

Figure 4.9 Accumulated Adoption of HEV and Bass Model Projection

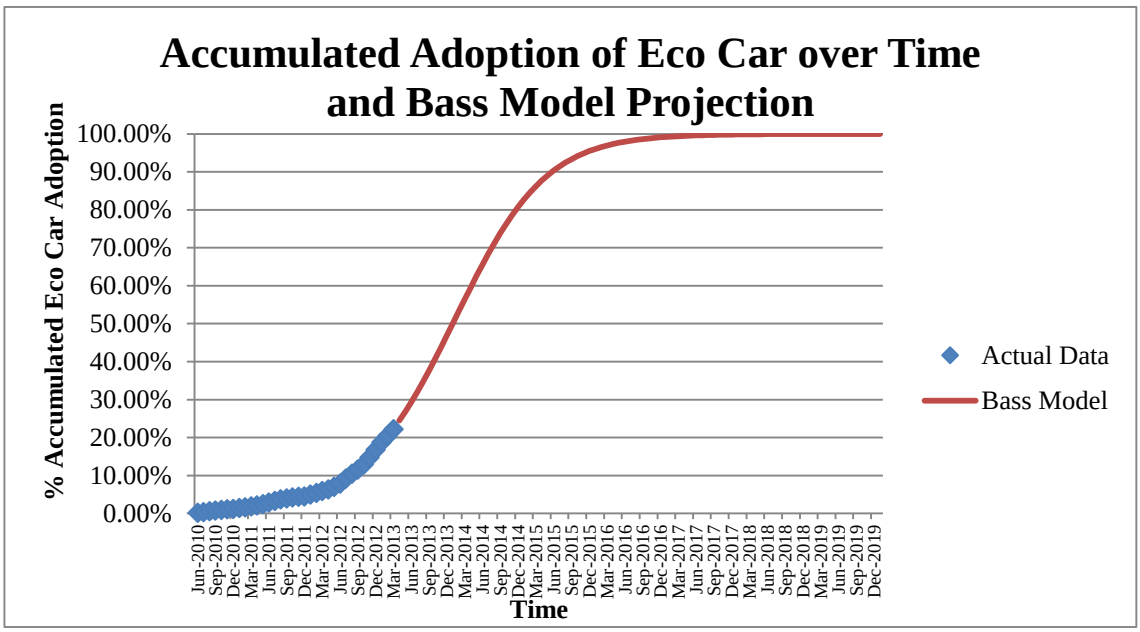

Figure 4.10 Accumulated Adoption of Eco Car and Bass Model Projection

The result shows that *p* of HEV is 3.68 times greater than which of eco car. On the

contrary, *q* of eco car is 1.65 times greater than which of HEV. However, both HEV and eco car adopters are mainly imitators and the importance of innovators diminishes monotonically. This makes the time eco car used to diffuse to saturation point faster than the time used by HEV as shown in figure 4.16 and 4.17.

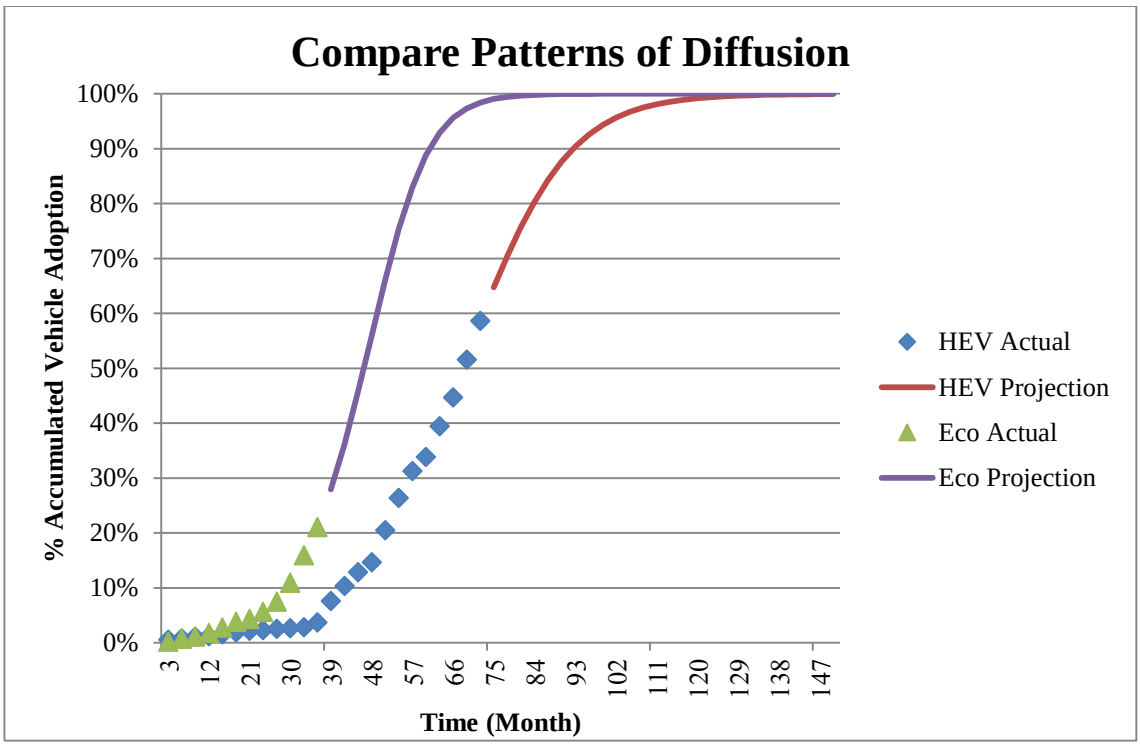

Figure 4.11 Comparisons of HEV and Eco Car Diffusions (%)

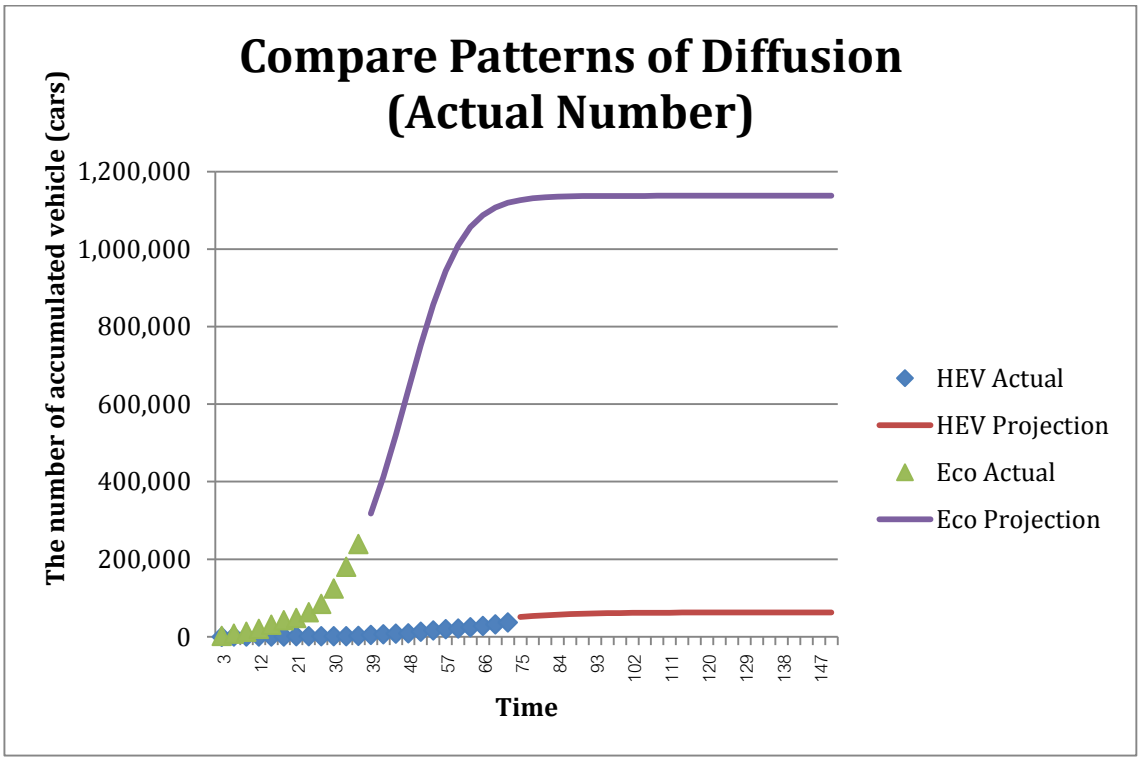

Figure 4.12 Comparisons of HEV and Eco Car Diffusions (Actual Number)

Another way to use parameter of Bass model is to calculate the time to peak sale. According to *A New Product Growth Model Consumer Durables (1969)*, Frank M. Bass, defines t^* as the number of years to peak sales. t^* will equals to the equation as follows.

$$t^* = \frac{\ln\left(\frac{q}{p}\right)}{p+q}$$

Table 4.12 Result Obtained from Using Parameters

	HEV	**Eco Car**
t* (months)	About 56 - 57	About 47 - 48
From t_0 to now (the end of March 2013)	72	36
Accumulation of registered Car :m (at the end of 2012)	58.62%	15.93%
75% to Saturation Point	Next 18 months (9/2014)	Next 6 months (9/2013)
90% to Saturation Point	Next 24 months (3/2015)	Next 13 months (3/2014)

The projected result shows that HEV sales passed the peak whereas sales of eco car will reach its peak in a year. Thus, if each parameters of Bass model parameters (*p, q, m*) remain the same, HEV sales trend is downturn while eco car sales trend will continue growing up for a year and reverse its trend afterwards. Moreover, the result also shows that adoption ratio of HEV and eco car will reach 90% of potential adopters in about two years and 13 months respectively. The short time left shows how necessary it is to make any strategic plans in advance especially for eco cars (shorter time left to reach saturation point) so as to get them ready for the near future.

4.3 Government Policy Suggestion

As shown in figure 2.3, to encourage fuel efficient vehicle adoption, there are many policies enforced or used to be enforced in many countries. Anyways, all the policies can be classified into 3 groups as follows.

1. Financial incentives
    1) Tax exemption/reduction
    2) Tax rebate
    3) Bonus
    4) Free/discounted registration fee
    5) Annual circulation tax (some countries call “Road tax”) exemption/reduction
    6) Income tax deduction
    7) Car parking charge
2. Non-financial incentives
    1) Green license plate (Ontario)
    2) Special lane
3. Financial disincentives for other vehicles by using “Polluter Pays” principle
    1) More vehicle taxes

2) Higher the certificate of entitlement (COE)/registration fee
3) Fuel cost
4) Surcharge annual circulation tax especially for the old car

However, Thailand does not have laws or facilities to support every aforementioned policy. Only excise tax rebate (First car scheme) and "Polluter Pays" principle (Excise tax and annual circulation tax) are put into practice so as to encourage fuel efficient vehicle adoptions.

4.3.1 First Car Scheme

On September 13, 2011 the cabinet approved an excise tax deduction scheme for whoever buying the first car according to what the Excise Department, the Ministry of Finance had proposed. The criteria for cars in accordance with this scheme are as follows.

1) The cars must be purchased from 1 October 2011 to 31 December 2012. (July 30, 2012: The cabinet agreed to extend the deadline for the car delivery under the first car scheme
2) The car's retail price must not more than 1,000,000 Baht/car (Pick Up/ Double Cab.)
3) Its cylinder capacity must not more than 1,500 cc (Passenger Car)
4) The car must be a domestic product. (Not including any car assembled from import components)
5) The buyer can get a refund as equal as the tax being paid, but not more than 100,000 Baht.
6) The buyer must be 21 years old or more.
7) The buyer owns the car for not less than 5 years.
8) Car owner will get a refund after owning the car for more than 1 year (start refunding from October 1, 2012).

This policy is one kind of financial incentives (tax rebate). As shown in table 2.3, there are many difference compared with many foreign tax rebate policies which could summarize as follows. (Table 4.13)

Table 4.13 First Car Scheme and Other Foreign Tax Rebate Policies

	First car scheme	**Foreign tax rebate policy**
1. End of scheme determination	• Time	• Time • Predetermined budget • The number of qualified applicants
2. Condition (Vehicle)	• Price • Cylinder capacity • Manufacturer's origin	• Type of vehicles • Fuel economy • CO_2 emission
3. Condition (Buyer)	• Age • Car ownership status	No

Table 4.13 First Car Scheme and Other Foreign Tax Rebate Policies (Continued)

	First car scheme	**Foreign tax rebate policy**
4. Objective	Raising the people's standard of living by enhancing domestic purchasing power and creating balance and strength with quality in the macroeconomic system (The Government Public Relations Department ,2012)	Spurring adoption of specific vehicles
5. Refund Rate	• Fixed	• Fixed • Decrease when time pass

Due to the fact that this policy is to raise the people's standard of living, it has both negative and positive impacts to eco car adoption. On the one hand, it makes the price of eco cars more affordable. On the other hand, this scheme narrows the price gap between eco cars and B-segment. Normally, the average prices of starting model of eco cars and B-segment vehicles (data from table 4.18 excluding KIA Picanto) are 415,057 and 572,181 Baht respectively while the tax refund for starting model of eco car and B-segment vehicle are 59,667 and 100,000 Baht respectively. This makes the gap of average price of starting model reduce from 157,124 to 116,791 Baht. The fewer gap might make some people who intend to buy eco car at first change their mind to buy B-segment vehicle.

Thus, if the government has a plan to encourage adoption of fuel efficient vehicles in the future, type of vehicles, fuel economy and CO_2 emission are recommended to use as criteria.

Table 4.14 Passenger Cars Conforming to First Car Scheme

Type (Excise Tax Rate)	Brand	Model	Grade	Model	Year	Engine (cc)/H.P.[2]	Price (Baht)[2]	Excise Tax Rebate (Baht)	Price after Tax Rebate (Baht)
Eco Car (17%)	*Nissan*	*March*	Starting Price	1.2 S MT	2012	1,198/79	380,000	53,000	327,000
			Top Model	(K13) 1.2 VL CVT Sport Version	2012		563,800	79,000	484,800
		Almera	Starting Price	(N17) 1.2L E 5MT	2011	1,198/79	429,000	57,000	372,000
			Top Model	(N17) 1.2L CVT	2011		599,000	95,000	504,000
	Honda	*Brio*	Starting Price	S MT	2011	1,198/90	399,900	63,000	336,900
				S MT (Y13)	2012		433,500	65,000	368,500
			Top Model	V AT	2011		508,500	73,000	435,500
		Brio Amaze	Starting Price	S MT	2012	1,198/90	454,000	65,000	389,000
			Top Model	V AT CVT	2012		521,000	73,000	448,000
	Suzuki	*Swift*	Starting Price	GA 1.25L 5MT	2012	1,242/91	429,000	65,000	364,000
			Top Model	GLX 1.25L	2012		559,000	79,000	480,000
	Mitsubishi	*Mirage*	Starting Price	GL M/T	2012	1,193/78	380,000	55,000	325,000
			Top Model	GLS Ltd A/T CVT	2012		546,000	77,000	469,000

Source: Excise Department, Ministry of Finance
Source2: http://www.checkraka.com/price/

Table 4.18 Passenger Cars Conforming to First Car Scheme (Continued)

Type (Excise Tax Rate)	Brand	Model	Grade	Model	Year	Engine (cc)/H.P.[2]	Price (Baht)[2]	Excise Tax Rebate (Baht)	Price after Tax Rebate (Baht)
B-SEGMENT (30% : 25% for E20 compatible vehicle)	*Toyota*	*Vios*	Starting Price	1.5 J M/T	2012	1,497/109	531,000	100,000	431,000
			Top Model	1.5 G Limited A/T	2012		720,000	100,000	620,000
		Yaris	Starting Price	1.5 J Standard M/T	2012	1,497/109	555,000	100,000	455,000
			Top Model	1.5 RS	2012		734,000	100,000	634,000
	Mazda	*Mazda 2*	Starting Price	Sports Groove/ Elegance Groove	2012	1,498/103	550,000	100,000	450,000
			Top Model	Sports Maxx AT/ Sports Spirit AT (Racing Series)	2012		705,000	100,000	605,000
	Honda	*City*	Starting Price	S MT	2011	1,497/120	559,000	100,000	459,000
			Top Model	SV AT	2011		704,000	100,000	604,000
		City CNG	Starting Price	S CNG AT	2012	1,497/102	659,000	100,000	559,000
			Top Model	V CNG AT	2012		706,000	100,000	606,000
		Jazz	Starting Price	S MT	2011	1,497/120	590,000	100,000	490,000
			Top Model	SV AT	2011		715,000	100,000	615,000

Source: Excise Department, Ministry of Finance (2012)
Source2: http://www.checkraka.com/price/

Table 4.14 Passenger Cars Conforming to First Car Scheme (Continued)

Type (Excise Tax Rate)	Brand	Model	Grade	Model	Year	Engine (cc)/H.P.[2]	Price (Baht)[2]	Excise Tax Rebate (Baht)	Price after Tax Rebate (Baht)
B-SEGMENT (30% : 25% for E20 compatible vehicle)	*KIA*	*Picanto*	Starting Price	1.2EX/L Automatic	N/A	1,248/87	N/A	54,000	N/A
			Top Model	K1-AT (SE)	2011		551,000	80,000	471,000
		Rio	Starting Price	1.4 Automatic	2011	1,396/107	749,000	100,000	649,000
	Ford	*Fiesta 299*	Starting Price	Sedan 4D Manual	2010	1,388/95	549,000	100,000	449,000
			Top Model	Hatch Back 5D Automatic (Sport Powershift)	2012	1,499/109	594,000	100,000	494,000
	Chevrolet	*Aveo*	Starting Price	1.4 MT Base E20	2006	1,399/94	505,000	100,000	405,000
			Top Model	1.4 AT LSX E20	2006		624,000	100,000	524,000
		Sonic	Starting Price	Notchback 1.4 MT LS	2012	1,398/100	548,000	100,000	448,000
			Top Model	Hatchback 1.4 AT LTZ	2012		687,000	100,000	587,000
	DFSK	*V27*	Starting Price	1.3L LPG-MPI (Standard)		16	499,000	100,000	399,000
			Top Model	1.3L LPG-MPI (Equipped)			543,000	100,000	443,000
Hybrid (10%)	*Honda*	*Jazz Hybrid*	Starting Price		2012	1,339/88	768,000	57,000	711,000
			Brilliant White Pearl		2012		778,000	58,000	720,000

Source: Excise Department, Ministry of Finance (2012)
Source2: http://www.checkraka.com/price/

4.3.2 Excise Tax

There are many government incentives to attract people to buy fuel efficient vehicles and one of the most efficient ways is to make them more affordable. In Thailand, there are 3 types of taxes related to domestically produced vehicles and 4 types of taxes related to imported new vehicles.

- Excise tax = $\frac{\text{Factory Cost x Excise Tax Rate}}{(1-(1.1 \text{ x Excise Tax Rate}))}$

- Interior tax = Excise Tax x 0.1

- VAT = (Factory Price + Excise Tax + Interior Tax + Profit) x 0.07

- Imported Duty = (Cost + Insurance + Freight) x 0.8

Some countries like India (some states) use VAT exemption/reduction to make the price of vehicle type more attractive but Thailand chooses to use excise tax to control the price of vehicles. Excise tax has principle like first registration tax (fee) but the data used to calculate is different. Excise tax is defined by factory cost whereas first registration fee is defined by open market selling price.

The current auto excise tax structure is determined only by vehicle type, cylinder capacity and fuel compatibility. Anyways, the new auto excise tax structure is due to take effect on January 1, 2016 and takes level of CO_2 emission into consideration. (Table 4.15)

This policy impacts on both supply and demand sides. The former is that vehicle manufacturers have to adjust their technology and production plans in time, otherwise prices of their vehicles will be increased. The latter is that the policy will change consumer demand on vehicle via price controlled by excise tax.

This emissions-based vehicle tax uses both financial incentive and financial disincentive to encourage adoption of low emission vehicle (LEV). Eco car which has CO_2 emission less than 100 g/km lower will gain 3 - 5 % lower tax rate. This makes its price goes down while changed tax rates make price gap between low emission vehicle (LEV) and high emission vehicle. Consequently, the larger gap might attract some buyers to purchase LEV.

However, this new policy still bases on engine size on the assumption that larger engines use more fuel. With new technologies, this theory may no longer true because some large engines are more fuel-efficient and emit less CO_2 than smaller ones.

Some countries used this concept to calculate tax. For example, Ireland changes the method of tax calculation from being calculated on engine capacity to a system calculated on only CO2 Emissions. Malta also does not use cylinder capacity but value of the vehicle, combined CO2 emission level, particulate matter emissions (diesel only) and length of the vehicle to calculate the new motor vehicle registration tax. England uses CO2 emission level and type of fuel to calculate vehicle tax and also annual circulation tax.

Table 4.15 Auto Excise Tax Structure : Current VS New (2016)

Vehicle Type	Current Auto Tax Structure						New Auto Tax Structure				
	Cylinder Capacity (cc)	E0-10(%)	E20(%)	E85(%)	NGV (%)	EV/FCV /HEV (%)	Cylinder Capacity (cc)	CO_2	E0-20 (%)	E85/ NGV (%)	EV/FCV /HEV (%)
Passenger car	<= 2,000	30	25	22	20	10	<= 3,000	<= 100 g/km			10
								<= 150 g/km	30	25	20
	2,001-2,500	35	30	27				151 - 200 g/km	35	30	25
	2,501-3,000	40	35	32				> 200 g/km	40	35	30
	> 3,000	50					> 3,000		50		
Pickup Passenger Vehicle	<= 3,250	3					<= 3,250	<= 200 g/km	3		
								> 200 g/km	5		
	> 3,250	50					> 3,250		50		
Space Cab Pickup	<= 3,250	3					<= 3,250	<= 200 g/km	5		
								> 200 g/km	7		
	> 3,250	50					> 3,250		50		
Double Cab Pickup	<= 3,250	12					<= 3,250	<= 200 g/km	12		
								> 200 g/km	15		
	> 3,250	50					> 3,250		50		
PPV	<= 3,250	20					<= 3,250	<= 200 g/km	25		
								> 200 g/km	30		
	> 3,250	50					> 3,250		50		
Eco Car	Gasoline <= 1,300 Diesel <= 1,400	17					Gasoline <= 1,300 Diesel <= 1,400	<= 100 g/km	14	12	
								100 - 120 g/km	17		

Source: Excise Department, Ministry of Finance (2012)

4.3.3 Registration Tax and Annual Circulation Tax

In Thailand, there is no difference between registration tax and annual circulation tax for passenger type 1. Thus, first registration tax exemption/reduction policy cannot be enforced unless there is no law or act support. Anyways, Thailand has one section of Motor Vehicle Act B.E. 2522 (1979) called "Vehicle License Tax" which is the law determining annual circulation tax (Shown in table 4.16).

Table 4.16 Vehicle License Rate for Passenger Car (Type 1)

Vehicle License Tax Rate	
Passenger Car Type 1 (< 7 passengers)	
Cylinder Capacity (cc.)	**Baht per cc**
(a) not exceeding 600 cc	0.50
(b) exceeding 600 cc but not exceeding 1,800 cc	1.50
(c) exceeding 1,800 cc	4.00
Old Passenger Car Type 1 Discount Rate (> 5 years)	**Discount Rate (%)**
(a) 6 years	10
(b) 7 years	20
(c) 8 years	30
(d) 9 years	40
(e) More than 10 years	50

Source: Motor Vehicle Act B.E. 2522 (1979)

This kind of policies is another way to reduce carbon dioxide emission rates of new passenger vehicles. Klier and Linn (2012) study about relationship between vehicle tax and CO_2 emissions in France, Germany, and Sweden by using new vehicle registration data from 2005–2010. The result shows that a vehicle's tax is negatively correlated with its registrations in all three countries.

However, Thailand's current vehicle tax rate does not benefit HEV's owner and has very few gaps of tax between eco car and B-segment vehicle because it uses cylinder capacity to calculate this annual tax.

Thus, to make this law efficiently to reduce carbon dioxide emission rates, CO_2 emissions should be put under consideration so as to make fuel efficient vehicle such as HEV and eco car pay less vehicle tax and/or use "Polluter Pays" principle to put burden on vehicle with high CO_2 emissions.

Another way is to reduce/exempt this kind of tax for certain period. For example, in Germany, BEV and PHEV are exempt from the annual circulation tax for a period of five years from the date of their first registration.