



**COMPARATIVE STUDY OF HYBRID ELECTRIC VEHICLE AND
ECO CAR DIFFUSION IN THAILAND**

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**A SPECIAL RESEARCH PROJECT SUBMITTED IN PARTIAL
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(ENTREPRENEURSHIP MANAGEMENT)
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A Special Research Project Submitted in Partial Fulfillment of the Requirements for the
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Abstract

This research studies about diffusion patterns of hybrid electric vehicle (HEV) and eco car in Thailand by analyzing the data of new registered vehicles during 2007 – 2012 as proxies of sales. The fundamental analysis shows that there are three factors related to pattern of HEV and eco car adoptions including new product launch, changes of oil price and government incentives.

The Bass model is another method used to find the diffusion of both types of vehicle. The result shows that the coefficient of imitation (q) is greater than the coefficient of innovation (p) in both cases. That means the majority of adopters of HEV and eco car are influenced by their peers' behavior and the number of people who are already adopted a new technology.

However, although p_{HEV} (0.00225) is greater than $p_{Eco Car}$ (0.00061), the number of innovators of eco car is greater than HEV because the total potential adopters of eco car (~1,137,361) are significantly greater than which of HEV (~62,683). While $q_{Eco Car}$ (0.44017) is about two time higher than q_{HEV} (0.24856) This make the number of eco car adopters reaches its saturation level faster than which of HEV.

All aforementioned consequences reflect that the encourage policies in using of eco cars are more necessary than stimulating HEVs' policy.

Keywords : Diffusion of Innovation / Bass Model / Hybrid / Eco Car

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บทคัดย่อ

งานวิจัยนี้ศึกษาลักษณะการแพร่กระจายของการใช้งานรถยนต์ไฮบริดและรถยนต์อีโคในประเทศไทย โดยใช้ข้อมูลจดทะเบียนใหม่ในระหว่างปี พ.ศ. 2550 – 2555 แทนยอดขายรถในช่วงเวลาดังกล่าว ผลจากการวิเคราะห์พื้นฐานพบว่า มีปัจจัย 3 ปัจจัย ที่มีผลการแพร่กระจายของการใช้งานรถยนต์ไฮบริดและรถยนต์อีโคในประเทศไทย ได้แก่ การออกรถยนต์ใหม่ การเปลี่ยนแปลงราคาน้ำมันและนโยบายจูงใจจากรัฐบาล

โมเดลของบาสเป็นเครื่องมืออีกอย่างหนึ่งที่ใช้ในการศึกษาการแพร่กระจายของการใช้งานรถยนต์ทั้งสองชนิด ผลการศึกษาพบว่าทั้งสองกรณีมีค่าสัมประสิทธิ์ของการเลียนแบบ (q) มีค่ามากกว่าสัมประสิทธิ์ของนวัตกรรม (p) ซึ่งเป็นสิ่งที่บ่งชี้ว่าผู้ใช้และมีแนวโน้มจะใช้รถยนต์ไฮบริดและรถยนต์อีโคส่วนใหญ่เป็นบุคคลที่ได้รับอิทธิพลมาจากพฤติกรรมของบุคคลรอบข้างซึ่งเคยใช้เทคโนโลยีเหล่านี้มาก่อน (Imitator) มากกว่าบุคคลที่มีการตัดสินใจใช้เทคโนโลยีใหม่ด้วยตัวเอง (Innovator)

แม้ว่า p_{HEV} (0.00225) จะมีค่ามากกว่า $p_{Eco Car}$ (0.00061) แต่จำนวนผู้ใช้เริ่มต้นของรถยนต์ไฮบริดกลับมีค่ามากกว่าเพราะจำนวนผู้ใช้ทั้งหมดที่เป็นไปได้ของรถยนต์อีโค (~1,137,361) มีค่ามากกว่าจำนวนผู้ใช้ทั้งหมดที่เป็นไปได้ของรถยนต์ไฮบริด (~62,683). เป็นอย่างมาก ในขณะที่ $q_{Eco Car}$ (0.44017) มีค่ามากกว่า q_{HEV} (0.24856) เกือบสองเท่า ทำให้จำนวนผู้ใช้รถยนต์อีโคจะถึงจุดอิ่มตัวเร็วกว่ารถยนต์ไฮบริด ผลลัพธ์ทั้งหมดที่กล่าวถึงในข้างต้นสะท้อนให้เห็นว่านโยบายการกระตุ้นการใช้รถยนต์อีโคมีความจำเป็นมากกว่านโยบายการกระตุ้นการใช้รถยนต์ไฮบริด

คำสำคัญ : การแพร่กระจายของนวัตกรรม / โมเดลของบาส / รถยนต์ไฮบริด / รถยนต์อีโค

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LIST OF TECHNICAL VOCABULARIES AND ABBREVIATIONS

GHG	=	Greenhouse Gas
IPCC	=	Intergovernmental Panel on Climate Change
CO ₂	=	Carbon Dioxide
PTT	=	PTT Public Company Limited
cc	=	cubic centimetre
H.P.	=	Horse Power
HEV	=	Hybrid Electric Vehicle
PHEV	=	Plug-in Hybrid Electric Vehicle
BEV	=	Battery Electric Vehicle
FCV	=	Fuel Cell Vehicle
LEV	=	Low Emission Vehicle
CV	=	Conventional Vehicle
mpg	=	Mile per gallon

CHAPTER 1 INTRODUCTION

For over a decade, not only have people been expressed their concerns over the issue of rising oil prices, but also have anxieties about greenhouse gas emitted by transportation sector which has remained mostly widespread. The world energy situation and global warming put pressure on many countries to find feasible solutions. Developing technology to use fossil fuels more efficiently while reducing pollution emissions or switching from carbon neutral and negative fuels usage to alternative fuels are such good examples of energy technology innovation.

1.1 Background

Greenhouse gases (sometimes abbreviated GHGs) are any of various gaseous constituents of the atmosphere, both natural and anthropogenic, which absorb and emit radiation at specific wavelengths within the spectrum of thermal infrared radiation. This property traps heat in the atmosphere, and contributes to the global warming.

Concerning this important environmental problem, the international agreement called “Kyoto Protocol” was adopted on 11 December 1997 and entered into force on 16 February 2005. This agreement linked to the United Nations Framework Convention on Climate Change (UNFCCC) commits its parties by setting reduction targets of internationally binding emission. The targets cover the emissions of the six main greenhouse gases, namely: Carbon dioxide (CO₂), Methane (CH₄), Nitrous oxide (N₂O), Hydrofluorocarbons (HFCs), Perfluorocarbons (PFCs), and Sulphur hexafluoride (SF₆).

In 2010, United States Environmental Protection Agency estimated the total national GHG emissions and removals associated with human activities. The primary sources of GHG emissions in the United States are electricity production (34%), transportation (27%), industry (20%), businesses and homes (11%), and agriculture (7%).

In case of Thailand, Thailand is classified into *Non-annex 1 country*, which has no binding target to reduce GHG emissions but has to submit Inventory Report as part of National Communication to UNFCCC database.

According to 2nd *National Communication of GHG Inventory in Thailand* (JGSEE, 2010) prepared for Office of Natural Resources and Environmental Policy and Planning (ONEP), the estimation of GHG the emission during 2000 – 2004 was done by using 3 guidelines namely: Revised 1996 IPCC Guidelines for National Greenhouse Gas, 2000 IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories, and 2003 Good Practice Guidance for Land Use, Land-Use Change and Forestry. The primary source of GHG emissions is energy sector (as shown in figure 1.1) and the top three of this sector are energy industry (41.7%), transportation (28.0%) manufacturing industries, and construction (19.3%) respectively

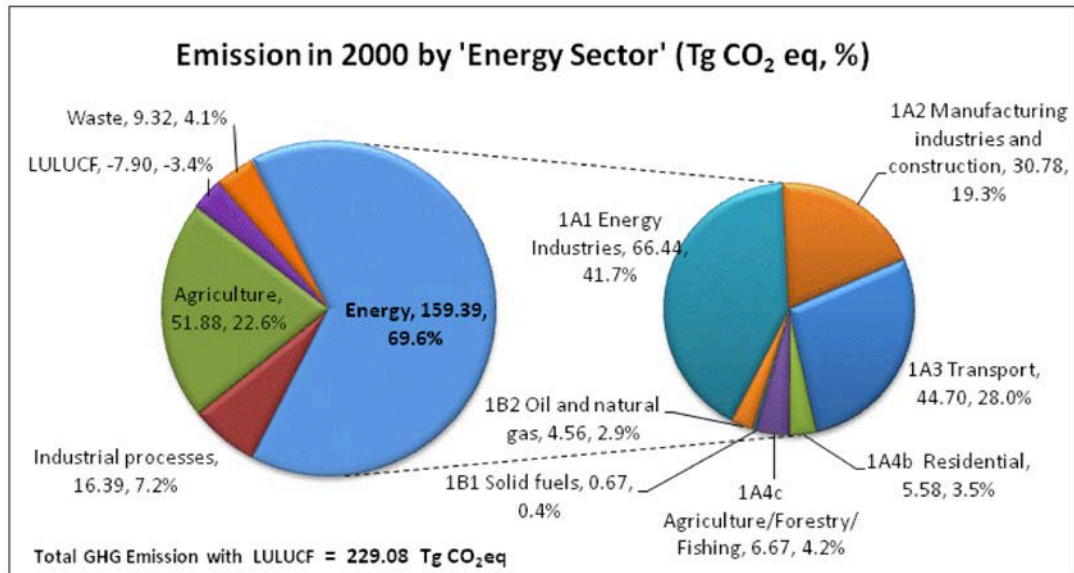


Figure 1.1 GHG Emissions

Source: Thailand's Second National Communication under the United Nations Framework Convention on Climate Change (2011)

Anyways, the biggest culprit behind global warming among these GHGs since the beginning of the Industrial Revolution is carbon dioxide (CO₂) and the majority of the anthropogenic emissions of CO₂ to the atmosphere come from combustion of fossil fuels. (Intergovernmental Panel on Climate Change: IPCC, 2001)

Focusing only on CO₂ emissions, the major sector emitting this kind of GHGs is electric production sector. In case of transportation sector, its CO₂ emission is slightly higher than industry sector even it does not use coal and lignite. Moreover, its increasing rate is relatively high compared to other economic sectors. (Table 1-1)

Table 1.1 CO₂ Emission Classified by Economic Sector

Unit : Million Tons CO₂

Economic Sector	2010	2011	Jan – Jun		Ratio (%)			Change (%)		
			2011	2012	2010	2011	2012*	2010	2011	2012*
Electric Production	90.0	87.2	44.6	46.2	40.8	39.4	39.5	8.1	-3.1	3.7
Transportation	57.6	59.8	30.3	32.0	26.1	27.0	27.3	2.1	3.9	5.5
Industry	54.2	54.6	27.4	28.0	24.6	24.7	23.9	6.9	0.8	2.3
Others	18.7	19.9	9.9	10.9	8.5	9.0	9.3	4.2	6.6	10.2
Total	220.4	221.5	112.2	117.1	100	100	100	5.9	0.5	4.4

*2012 = January – June, 2012

Adapted from Energy Policy Journal Issue 97 (July – September, 2012) pp. 47

Although CO₂ can be removed from the atmosphere through natural processes, increased production of anthropogenic CO₂ has exceeded natural absorption rates leading to higher CO₂ in the air. (Figure 1.2) Consequently, the over concentration of CO₂ and other GHGs in Earth's atmosphere results in disastrous global environmental consequences called "Global warming".

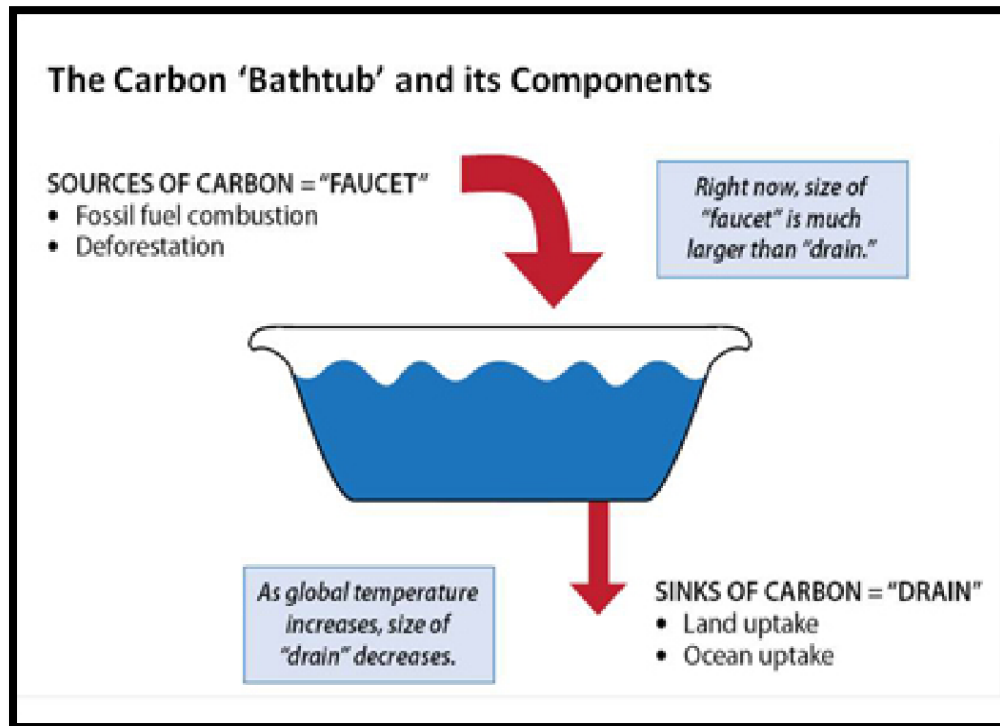


Figure 1.2 Carbon Bathtub

Source: U.S. EPA Climate Change (2012)

Apart from threatening people with global warming, petroleum-based fuel also straitens them with its price. Due to the fact that the world's oil resources dwindle down while demand skyrockets, the price will continue to be more and more expensive.

In publication *The World Bank Group's Response to the Global Economic Crisis* shows that there was an upward trend in the cost of fuel prior to the financial crisis, and partly in parallel with it. Unfortunately, the financial collapse and overlapping transformation from the initial U.S. financial crisis to the global economic crisis were major factors of increasing energy prices.

Referring to empirical data on E&P website, historical U.S.A. average price of gasoline and the highest diesel price in July, 2008, the prices retreated from the recent peak because of the Great Recession between late 2008 - early 2009. After that, it retraced the step and continued upward trend. Retail oil price (PTT) in Bangkok and metropolitan area between 2006 and 2012 also had the same trend. (Appendix A)

Thus, relying more on domestic fuels and importing less petroleum-based fuel will enhance the nation's energy security in the long run. Moreover, fuel price is considered being a major driver in the cost of vehicle ownership calculation. Due to an increase in

fuel price, a car fuel economy drives more consumers buying decision. (Pathumwan Nambutr, 2008)

On account of a combination of factors, such as environmental concerns and high oil prices, development of innovative energy technology has become a crucial priority for many governments and vehicle manufacturers around the world so as to relieve the problems. While government stimulates supply-push and demand-pull policies, automotive manufacturers play an important role as policy advocacy.

In addition to following the government's policies, exploiting this kind of technological innovation paves the way for manufacturers to create competitive advantages over their competitors. (Schilling, 2005)

On the one hand, vehicle manufacturers are on the forefront of developing engine and other technologies to boost fuel economy and efficiency. Pollution control technologies cannot reduce CO₂ emissions like other forms of pollution,. The only way to reduce them is to burn less fuel or to use other fuels that contain less carbon (Office of Energy Efficiency and Renewable Energy, 2012). The synthesis report to congress shows that vehicle and fuel efficiency strategies including developing and bringing to market advanced engine and transmission designs, using lighter-weight materials, improving vehicle aerodynamics, and reducing rolling resistance would bring about lower fuel use and lower emissions of transportation greenhouse gas. For example, advanced gasoline vehicles emit 8-to-30 percent of GHG less than that of a conventional vehicle. (U.S. Department of Transportation, 2010) Due to modern combustion technologies such as high precision gasoline injection, it reduces fuel consumption as well as CO₂ emission.

According to latest Fuel Economy guide (2011), 20 pounds of CO₂ is put into the atmosphere for every gallon of gasoline your vehicle burns and the average vehicle emits around 6 to 9 tons of CO₂ each year. The fewer miles per gallon vehicle burns, the lower amount of CO₂ is emitted into atmosphere. (Shown in figure 1.3)

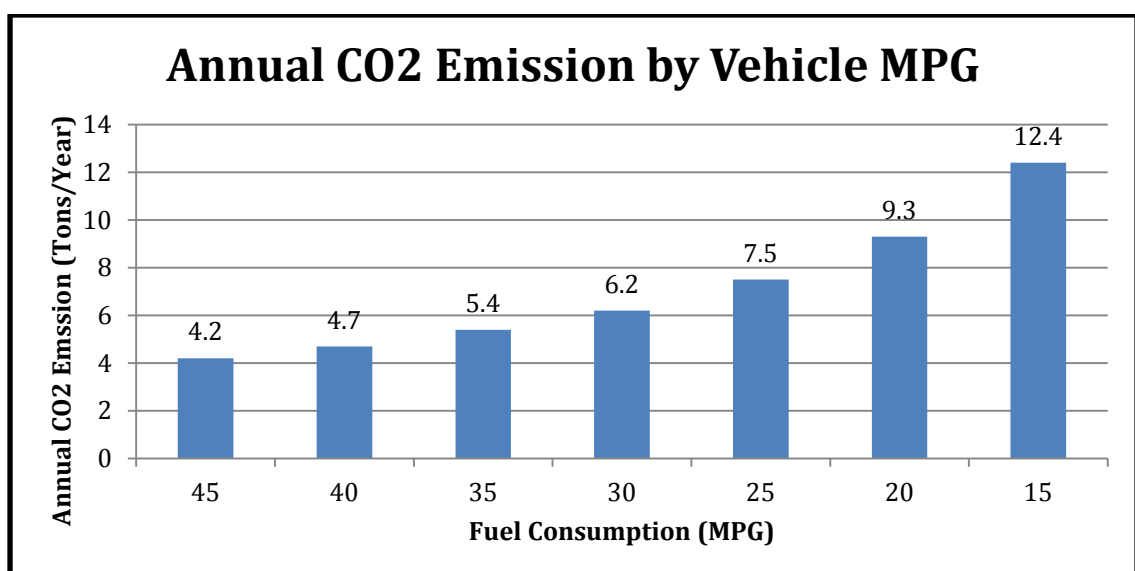


Figure 1.3 Annual CO₂ Emissions by Vehicle Miles per Gallon
Source U.S. Environment Protection Agency (2011)

On the other hand, vehicle manufacturers take great R&D efforts to innovate alternative fuel vehicles (AFVs). This refers to a vehicle that runs on a fuel other than traditional gasoline or diesel and also any methods of powering an engine that does not involve solely petroleum. According to Alternative Fuel Data Center (AFDC), designated alternative fuels include liquefied petroleum gas (LPG, also known as propane), compressed natural gas (CNG), ethanol, biodiesel, electricity and hydrogen.

In case of Thailand, to reduce the number of import foreign oil supplies and GHG emissions, the Ministry of Energy announced the policy to pursue the country own alternative sources of energy in 2007. A considerable part of this policy has been on promoting the use of eco car and innovative electrified vehicles. (Shown in table 1.2)

Table 1.2 Automotive Excise Taxes

Type	Condition & Excise Tax			
Passenger Car	< 2,000 cc & < 220 H.P. : 30%	2,000 - 2,500 cc & < 220 H.P. : 35%	2,500 - 3,000 cc & < 220 H.P. : 40%	> 3,000 cc or > 220 H.P. : 50%
E20 Compatible Car	< 2,000 cc & < 220 H.P. : 25%	2,000 - 2,500 cc & < 220 H.P. : 30%	2,500 - 3,000 cc & < 220 H.P. : 35%	> 3,000 cc or > 220 H.P. : 50%
E85 Compatible Car	1,780 - 2,000 cc & < 220 H.P. : 22%	2,000-2,500 cc & < 220 H.P. : 27%	2,500-3,000 cc & < 220 H.P. : 32%	
Passenger Pickup Vehicle (PPV)	< 3,250 cc : 20%		> 3,250 cc : 50%	
Single Cab Pickup	< 3,250 cc : 3%		> 3,250 cc : 50%	
Double Cap Pickup	< 3,250 cc : 12%		> 3,250 cc : 50%	
Natural Gas	20%			
NGV Retrofit	< 2,000 cc & < 220 H.P. : 30%	2,000 - 2,500 cc & < 220 H.P. : 35%	2,500 - 3,000 cc & < 220 H.P. : 40%	> 3,000 cc or > 220 H.P. : 50%
Eco-Car (Gasoline)	≤ 1,300 cc : 17%			
Eco-Car (Diesel)	≤ 1,400 cc : 17%			
Hybrid Vehicle	< 3,000 cc : 10%		> 3,000 cc : 50%	
Electronic Powered	10%			
Fuel Cell Powered	10%			

Source: Excise Department, Ministry of Finance (2012)

Among innovative electrified vehicles, this research chooses to focus only on Hybrid Electric Vehicle (HEV) and neglect Fuel Cell Vehicle (FCV), Plug-in Hybrid Electric Vehicles (PHEV) and BEV (Battery Electric Vehicle) due to the fact that PHEV and BEV in Thailand are not commercialized yet and get stuck in the unavoidable barrier. It is the lack of a widespread refueling infrastructure. This barrier is vicious cycle, and hard to overcome in the near future. In 2002, the U.S. Department of Energy (DOE) Federal Energy Management Program (FEMP) describes about this in *Alternative Fuel Vehicles* publication. “potential buyers might hesitate to purchase AFVs in large

volume until commercial refueling stations are readily available. At the same time, station owners might hesitate to invest in the refueling infrastructure until there are enough AFVs to make it a good investment.” Moreover, Michalek and his co-writers (2011) estimate life-cycle air emissions and oil displacement benefits of conventional vehicle (internal combustion) and other electrified vehicles relative to PHEVs. In addition, the result showed that in base case and pessimistic case (low gas price and electricity generated by coal fired power plant), PHEV and BEV could be more responsible for life-cycle emission externality damages and oil premium costs (except PHEV 20; base case). Also, they have more than net present value (NPV) of lifetime private ownership cost over the HEV.

Thus, HEV becomes interesting alternatives to conventional engine vehicle because of higher fuel economy by combining propulsion systems between a conventional engine and a rechargeable battery to provide motive power. The increased fuel economy of hybrids makes HEVs more attractive to consumers.

Nowadays, there are many hybrid models officially marketed in Thailand as shown in Table 1.3.

Table 1.3 List of Officially Marketing Hybrid Car in Thailand

Model	Engine (litres) g-gasoline d-diesel	Official Debut in Thailand	Price (Baht)		
			Normal	Standard Grade	Top Option Grade
Toyota Camry Hybrid (XV40)	2.4 g	2008	N/A	1,599,000	1,779,000
Toyota Camry Hybrid (XV50)	2.5 g	3/2012	1,499,000 (2.5 G A/T)	1,649,000	1,869,000
Toyota Prius Generation 3	1.8 g	11/2010	NEM	1,199,000	1,369,000
Alphard Hybrid	2.4 g	2012	3,339,000 (2.4 V)	3,459,000	
Toyota Prius C	1.5 g	3/2012	NEM	1,390,000	
Honda Jazz Hybrid	1.3 g	7/2012	NEM	768,000	
Honda Civic Hybrid	1.5 g	3/2013	828,000 (1.8 S A/T)	1,035,000	1,095,000
Honda CR-Z	1.5 g	8/2012	NEM	1,975,000	
Lexus CT 200h	1.8 g	2/2011	NEM	2,215,000	2,920,000
Lexus RX450h Generation 2	3.5 g	2012	NEM	6,990,000	
Lexus GS450h	3.5 g	3/2012	NEM	7,790,000	
Lexus LS600h	5.0 g	N/A	NEM	13,580,000	
Benz E300 Bluetec hybrid	2.1d	3/2013	NEM	4,199,000	4,499,000

NEM = No Equivalent Model, N/A = Not Available

Table 1.3 List of Officially Marketing Hybrid Car in Thailand (Continued)

Model	Engine (litres) g-gasoline d-diesel	Official Debut in Thailand	Price (Baht)		
			Normal	Standard Grade	Top Option Grade
BMW Active Hybrid 3	3.0 g	3/2013	NEM	4,199,000	4,499,000
BMW Active Hybrid 5	3.0 g	2012	NEM	5,399,000	5,599,000
BMW Active Hybrid 7	3.0 g	3/2013	NEM	8,299,000	8,999,000
Porche Cayenne S Hybrid	3.0 g	03/2012 (AAS)	NEM	7,900,000	
Porche Panamera S Hybrid	3.0 g	03/2012 (AAS)	NEM	9,600,000	

NEM = No Equivalent Model, N/A = Not Available

While HEV uses new technology of combining propulsion systems to increase fuel economy, eco car uses another method by downsizing engine. According to UNECE standard, there are 4 criteria eco car must pass and the first one is that vehicle that can be eco car have to consume fuel less than 5 liters per 100 kilometers under combine mode testing UNECE Reg. 101 Rev. 1. Moreover, eco car must emit CO₂ less than 120 grams/ kilometers and pass the UNECE crashworthiness standards R94 (protection of the occupants in the event of a frontal collision) and R95 (protection of the occupants in the event of a lateral collision). Nowadays, there are 6 models of eco cars passing these criteria and officially introduced. (Table 1.4)

Table 1.4 Lists of Officially Marketing Eco Cars in Thailand

Brand	Model	Type	Engine Size	Price (Baht)
Nissan	March	Hatchback	1.2 L	380,000 – 563,800
	Almera	Sedan	1.2 L	429,000 – 599,000
Suzuki	Swift	Hatchback	1.25 L	429,000 - 559,000
Mitsubishi	Mirage	Hatchback	1.2 L	380,000 – 546,000
Honda	Brio	Hatchback	1.2 L	433,500 – 508,500
	Brio Amaze	Sedan	1.2 L	454,000 – 521,000

Special Criteria: Additional to aforementioned criteria, if and only if the car is domestic manufactured, it is classified as “eco car”.

Although HEV and eco car are fuel-economy vehicle, the natures of these two types of vehicle are extremely different. Thus, it is interesting to explore the diffusion pattern of these 2 innovations.

1.2 Objectives of the Study

- 1) To explore the pattern of diffusion between HEV and eco car in Thailand
- 2) To suggest government policies to encourage HEV and eco car adoption

1.3 Significance of the Study

1) Saturation level and curve of adoption are alternative guides for helping Thai government make policy and regulation to promote HEV and eco car adoption as well as help vehicle manufacturers make time-plan for new product launching.

2) Suggested policies in this research could be used to promote rate of HEV and eco car adoption

3) The diffusion pattern of HEV could be used in future comparative study in diffusion of more efficient FCV using less fossil fuel and significantly emitting lower GHGs than a comparable HEV such as PHEV. (ERPI, 2007)

1.4 Scope and Limitation of the Study

1) According to Rogers (2003), there are 5 variables determining the rate of adoption of innovations. This research will focus only on communication channels and perceived attributes of innovations.

2) The research will use Bass diffusion model to find out diffusion patterns of HEV and eco car adoption. In case of HEV, this part will use secondary data, which is the number of new registered light duty vehicles type 1 (classified by type of fuel usage) obtained from Transport Statistics Sub-Division, Planning Division and Department of Land Transport. The available data are published every transitional quarter and cover the fiscal year 2007 – 2013 (January 2007 - December 2012).

3) In case of eco car, this research will use the number of new registered vehicles with engine size less than 1,300 cc as a proxy of eco car sales due to limitation of data. The available data are recorded monthly during April 2011 and March 2013 and classified by brand and size of engine.

4) This research focuses only on demand pull policies.

1.5 Definition of Terms

Hybrid Electric Vehicle (HEV): light duty vehicle with high fuel economy by combining propulsion systems between a conventional engine and a rechargeable battery to provide motive power.

Conventional Vehicle (CV): vehicle with internal combustion engine

Alternative Fuel Vehicle (AFV): vehicle that runs on a fuel other than "traditional" petroleum fuels (gasoline or diesel), or uses any technology of powering an engine that does not involve solely petroleum

Eco Car: domestically manufactured vehicle with engine size under 1,300 cc for gasoline engine or 1,400 cc for diesel engine which has fuel consumption less than 20 kilometers/liter, emits CO₂ less than 120 grams/ kilometer and also pass these UNECE crashworthiness standards R94 (protection of the occupants in the event of a frontal collision) and R95 (protection of the occupants in the event of a lateral collision).

Except in the analysis part: The definition is defined the vehicle with engine size under 1,300 cc. under 4 brands as follow.

- 1) Nissan : as proxies of Nissan March and Nissan Almera
- 2) Honda : as proxies of Honda Brio and Honda Brio Amaze
- 3) Mitsubishi : as proxy of Mitsubishi Mirage

4) Suzuki : as proxy of Suzuki Swift (1.25L)

CHAPTER 2 LITERATURE REVIEW

2.1 Innovation

“Innovation” derives from Latin word “Innovare” stemming from in - “into” and novus - “new”. (Wikipedia, 2555) While they are close in stature and commonly confused, there is a subtle difference between these “Innovation” and “Invention”. Invention is first occurrence of new ideas for products or processes while innovation is the first attempt to carry the idea into practice and commercialize of new, ameliorated existing, processes, products and/or services. (Rogers, 2003; Tiwari, 2007)

This research probes into many books and academic papers so as to find concurrence in each scholar’s definition. The result shows that all the definitions have concurrence in at least two out of three aspects as shown in Table 2.1.

- 1) The exploitation of change and/or creative idea
- 2) Creating something new or improving existing
- 3) Creating/Adding economic value

Table 2.1 Definition of Innovation

Scholar	Definition	(1)	(2)	(3)
Schumpeter (1934, p.65)	“New combinations of new or existing knowledge, resources, equipment and so on.”	x	x	
Utterback and Abernathy (1975, p.642)	“A new technology or combination of technologies introduced commercially to meet a user or a market need.”	x		x
Drucker (1985, p.19)	“Innovation is the specific tool of entrepreneurs, the means by which they exploit change as an opportunity for a different business or a different service.”	x		x
Freeman & Soete (1997 p.1-2)	“The first commercial application or production of a new process or product ... fundamental sense of people to do things which have never been done before.”		x	x
Betje (1998, p.1)	“Innovations are new things applied in the business of producing, distributing and consuming products or services.”	x	x	x
Rogers (2003, p.12)	“An innovation is an idea, practice, or project that is perceived as new by an individual or other unit of adoption.”	x		x
Tidd, J. & Bessant, J. (2009, p.68)	“Innovation is more than simply coming up with good ideas; it is the process of growing them into practical use.”	x		x
National Innovation Agency - Thailand (2010)	“Innovation is new things or concepts derived from the exploitation of knowledge and creativity, leading to enhancement of social and economic value.”	x	x	x

2.2 Diffusion of Innovation

The research in diffusion of innovations has occurred for more than a century by French sociologist named “Gabriel Tarde”. *Three Laws of Imitation*, his renowned work engaging in crime, include (1) the law of close contact, (2) the law of imitation of superiors by inferiors, and (3) the law of insertion. (Williams, n.d.) It explains that the whole of social behavior derives from acts of an individual and the diffusion through the imitation process which beliefs and desires or motives transmitted from one individual to another. (Katz, 2006) Tarde also claimed that the most innovations have an S-shaped innovation curve and the slopes of the curve reflect their rate of adoption. (Figure 2.1)

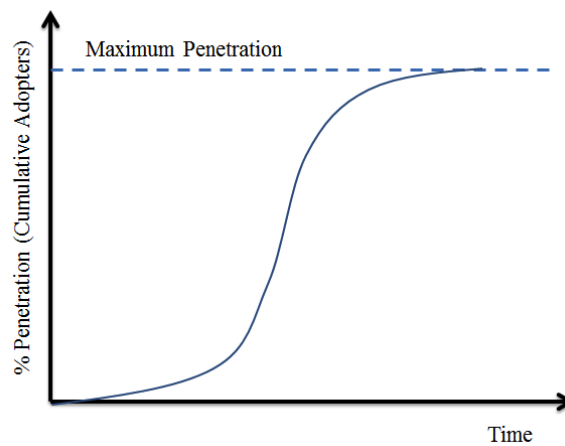


Figure 2.1 S-Curve

Rogers first introduced the phrase “*the process by which an innovation is communicated through certain channels over time among the members of a social system*” in his book named “*Diffusion of Innovations*” and also defined the rate of adoption as “*the relative speed with which an innovation is adopted by members of a social system*”. This kind of diffusions is an uncertainty reduction process through five characteristics of innovations perceived by individual. Rogers (2003) defined these five attributes as following.

1) Relative advantage: “The degree to which an innovation is perceived as relatively difficult to understand and use”

2) Compatibility: “Compatibility is the degree to which an innovation is perceived as consistent with the existing values, past experiences, and needs of potential adopters”

3) Complexity: “The degree to which an innovation is perceived as relatively difficult to understand and use”

4) Trialability: “The degree to which an innovation may be experimented with on a limited basis”

5) Observability: The degree to which the results of an innovation are visible to others”

These five attributes determine between 49 and 87 percent of the variance in the rate of adoption of innovations (Rogers, 2003) and can help identify when improving products or behaviors to eliminate weaknesses. (Robinson, 2009) In addition to these aforementioned attributes, the innovation-decision type (optional, collective, or authority), communication channels (mass media or interpersonal channels), social

system (norms or network interconnectedness), and change agents may increase the predictability of the rate of adoption of innovations. (Figure 2.2)

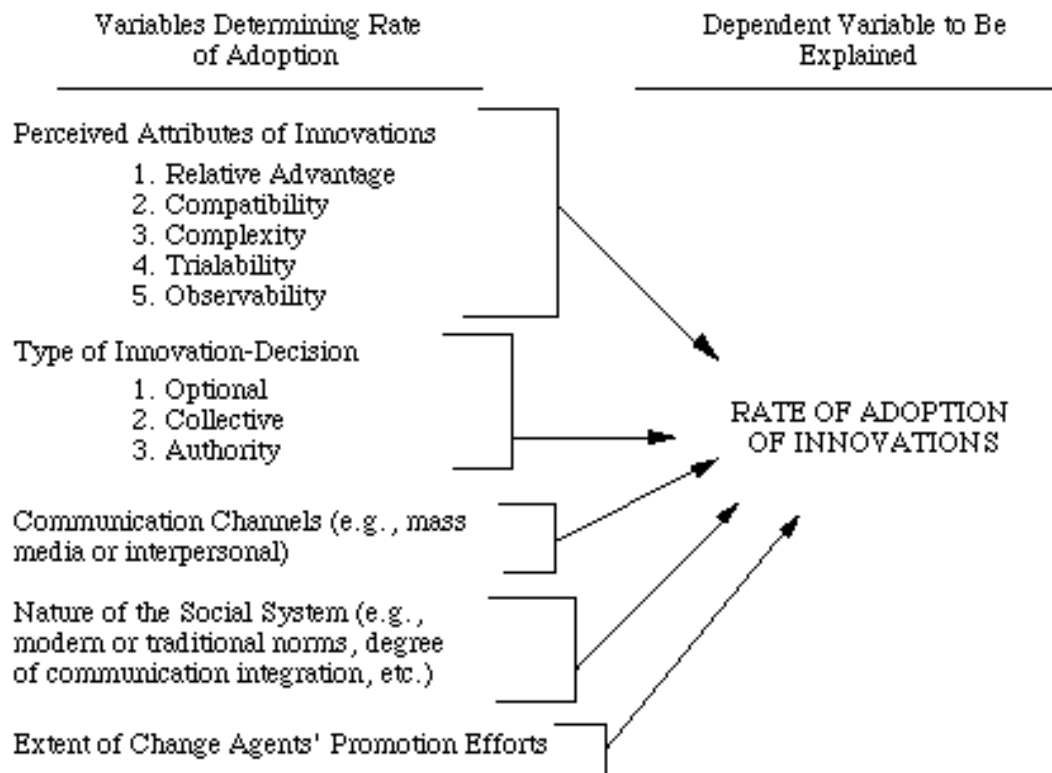


Figure 2.2 Variables Determining the Rate of Adoption of Innovations
Source: Rogers, (2003)

The members of a social system on the basis of innovativeness are categorized into five groups: innovators, early adopter, early majority, late majority, and laggards. (Rogers, 2003) The personal characteristics and behavior of these adopters are different from each other as shown in Table 2.2.

Table 2.2 Members of a Social System on the Basis of Innovativeness

Group	Ratio	Characteristic	Behavior
Innovators	2.5%	Venturesome / Technology Enthusiasm / Gadget Freak / Close relationship outside the social system	Try out any new technology/ideas within their field.
Early Adopters	13.5%	Visionary / Positive attitude toward technology / Opinion Leader / Well respected by peers	Judge worthiness of new ideas/technologies carefully before adopting any innovations
Early Majority	34%	Pragmatic / Thoughtful people	Postpone adopting new ideas/technologies until there are established support structures and an emerging market leader

Table 2.2 Members of a Social System on the Basis of Innovativeness (continued)

Group	Ratio	Characteristic	Behavior
Late Majority	34%	Skeptic / Conservative / Cautious about new ideas	Look for new ideas or products that have been around for a while and have been used by the majority (reaction to peer pressure and emerging norm)
Laggards	16%	Traditional / Suspicious of innovations / Risk-averse / Doing things the way they always have	Only purchase technology when current solutions become obsolete and have no other choice

Conclusion from *Diffusion of Innovation, 5th Edition* by Rogers (2003)

There are 3 ways categories of adopters can be used. (Straker, n.d.)

- 1) Idea generation phase: Identifying people who can help you.
- 2) Implementation phase: Classifying the target customers.
- 3) Commercialization phase: Identifying appropriate actions to get customer consent

2.3 Bass Diffusion Model

This research tries to forecast the trend of HEV and eco car diffusion pattern by looking at the adoption pattern in the past and extrapolating into the future. This method is “reliable, objective, inexpensive, quick, and easily automated” (Armstrong, 2001). There are three well-known market growth models such as Bass, Logistic and Gompertz models for describing the S-shaped diffusion curve.

The Bass model has found widespread use to forecast the adoption of technological products and services (Dodds, 1973; Fernerion, 2003; Firth et al., 2006; Michalakelis et al., 2008; Chu and Pan, 2008; Wu and Chu, 2010 cited in Naseri and Elliott, 2013) and some researchers found that the Bass model outperformed the Logistic and the Gompertz models. (Young, 1993; Naseri and Elliott, 2013)

Moreover, the Bass model appeared to outperform other models in case the upper limit of the market was unknown (Young, 1993) and the data used in this research have this constraint. Thus, this research chooses the Bass model to forecast the HEV and eco car adoptions.

The Bass diffusion model on the adoption and diffusion of new products and technologies is one of the most frequently referred to marketing models (Lilien et al. 1992, p. 471) created by Frank M. Bass, in a paper entitled: “*A new product growth model for consumer durables*”. The spread of many new consumer durable products can be by Bass formula. Thus, it can be used as market analytic and demand forecasting tools. The Bass model assumes that potential adopters are influenced by mass-media and word-of-mouth communication. It uses this concept to categorize adopters of an innovation into two groups. ‘Innovator’ is influenced only by the mass-media communication (external influence) and ‘Imitator’ is influenced only by the word-of-mouth communication (internal influence). (Mahajan et al., 1993)

There is important assumption characterizing Bass model. It is that the unit of sales over the period of interest will concur with the number of initial purchases. This model interests in the time interval for which replacement sales (repurchasing) are excluded. (Bass, 1969)

Suppose that the likelihood that individual who has not yet used an innovation will start using it at particular time t is given by $L(t)$. The instantaneous likelihood that individual in the target segment will purchase the innovation at particular time t is $f(t)$ and the cumulative probability that individual in the target segment will purchase the innovation by time t is $F(t)$. Using the mention-above definitions and Bayes' theorem, $L(t)$ can be summarized by the following mathematical equation.

$$L(t) = \frac{f(t)}{[1 - F(t)]} \quad \text{-- (1)}$$

In 1969, Bass proposed that $L(t)$ can be define as a linear function

$$L(t) = p + \left(\frac{q}{m}\right)N(t) \quad \text{-- (2)}$$

where

$N(t)$ = Total number of adopters of the innovation by time t

m = The market potential (potential adopter); the total number of people who will eventually use the product

p = The coefficient of innovation (or the coefficient of external influence); the likelihood that somebody who has not yet used the product will start using it because of mass media coverage or the external factors

q = The coefficient of imitation (or the coefficient of internal influence); the likelihood that somebody who has not yet used the product will start using it because of word of mouth or other influence from those already using the product

Equation (2) suggests that diffusion of a new technology depends on 2 main factors, innovation effect and imitation effect. Innovation effect drives adoption of "Innovators" who desire to try new technologies or methods by themselves. The number of other users does not influence on likelihood to adoption of this kind of people. In contrast to imitation effect, "Imitators" are influenced by their peers' behavior and the number of people who are already adopted a new technology. (Van den Bulte, 1999; Lamberson, 2008)

Equating (1) and (2) :

$$\frac{f(t)}{[1 - F(t)]} = p + \left(\frac{q}{m}\right)N(t) \quad \text{-- (3)}$$

Rearrange the equation

$$f(t) = \{p + \left(\frac{q}{m}\right)N(t)\}[1 - F(t)] \quad \text{-- (4)}$$

Defining the number of adopters at particular time t as $n(t)$ ($f(t) = \frac{n(t)}{m}$) and total number of adopters by time t as $N(t)$: ($F(t) = \frac{N(t)}{m}$)

$$n(t) = p(m - N(t)) + \left(\frac{q}{m}\right) N(t) (m - N(t)) \quad \text{-- (5)}$$

“ $p(m-N(t))$ ” represents adopters who are not influenced by the number of people who already bought the product in the timing of their adoption and “ $(q/m)N(t)(m-N(t))$ ” represents adopter who are influenced by the number of previous buyers. (Mahajan et al., 1993)

The equation shows that there will be both innovators and imitators buying the new product every period of time, but the relative number of innovators diminishes as time passes. The imitators offset this tendency and become increasingly important as the diffusion process continues. (George S. Day, 1986 cited by Christophe Van den Bulte, 1999) (shown in figure 2.3)

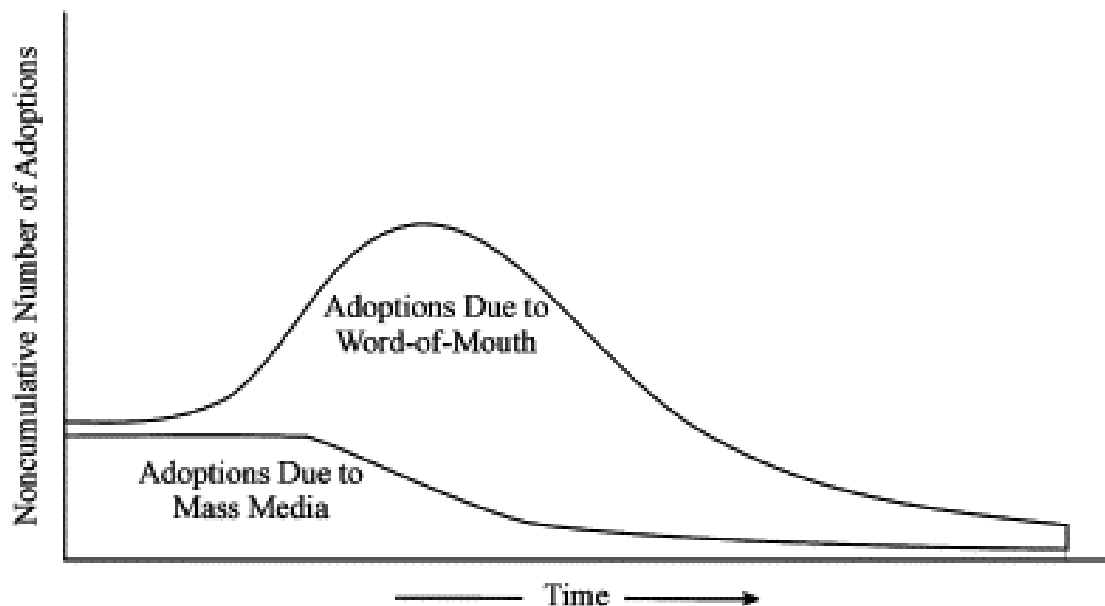
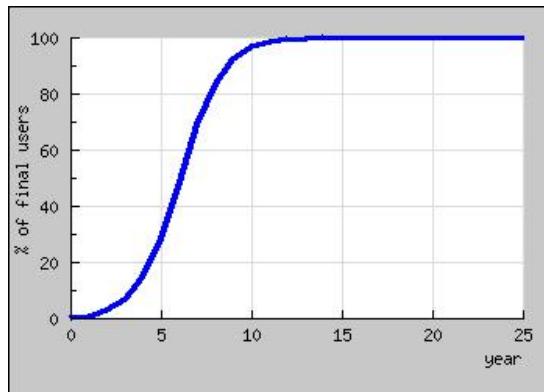
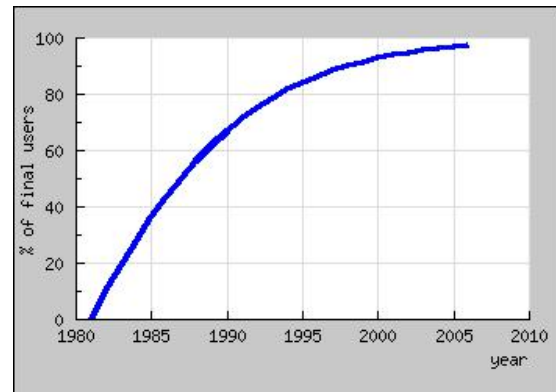


Figure 2.3 Innovators and Imitators
Source: J. Scott Armstrong (2001)

The uptake of innovation is more relevant to innovators than imitators because when $F(t)$ is close to 0, $F(t) = p$. After that the more time passes, the more diffusion curve shape is mainly depended on q . Thus, values of p and q shape the diffusion curve as shown in figure 2.4.



Source: Saltan (1990)
Colour TV (Mainly Imitation)
 $p = 0.005; q = 0.84$



Source: Lilien (1999)
Cable Television (Mainly Innovation)
 $p = 0.10; q = 0.06$

Figure 2.4 Diffusion Curve Pattern: Mainly Imitation vs Mainly Innovation

Note: All these figures are cited and generated in <http://jordi.pro/bass/>

2.4 Government Policies towards Low Emission Vehicles

Despite the fact that any innovations are able to diffuse by communication through certain channels over time among the members of a social system, some innovations like fuel efficient vehicles cannot be let to diffuse naturally. For example, Gallagher and Muehlegger (2008) studied about incentive and U.S. consumer adoption of hybrid vehicle technology. They described how this technology diffuses over time. At the beginning, consumers have imperfect information about hybrid vehicle technology in term of the quality, performance and durability.

Consequently, only some people with a strong preference or reliance on the quality of hybrid technology choose to initially adopt this kind of vehicle. After that, other consumers gradually observe or infer the quality of new technology from the early adopters. This procedure makes hybrid sales growing slowly. However, after incentive policies was implemented by federal, state and local governments, the domestic sales of hybrid vehicles increased substantially from fewer than 3,000 units in 2000 to more than 250,000 in 2006.

This is the main reason why there are many policies established by several national and local governments around the world as financial incentives and other non-monetary incentives so as to stimulate consumer adoption of fuel efficient vehicle like HEV, PHEV, BEV, FCV and some conventional internal combustion engine vehicles as shown in table 2.3 and Appendix B.

Table 2.3 Government Policies towards Low Emission Vehicle

	Tax Rebate / Bonus Payment	Exempt for Registration Tax	Exempt/Reduction for Other Taxes	Income tax Deduction	Carpool Lane	Annual Circulation Taxes Reduction/ Exemption	Disincentive Other Cars	Free Parking
Canada	x				x			
China	x					x		
Europe							x	
Austria	x	x	x (Fuel Consumption Tax)					
Belgium				x				
Czech Republic		x						
Germany						x (5 Years)		
Greece		x						
Italy						x (5 Years)		
Monaco	x							x
Ireland	x							
Sweden	x	x	x (Sales Tax)		x			x
Portugal	x							
Spain	x							
U.K.	x							
Japan	x							
U.S. (Including local policy)	x		x (Sales Tax)	x				x

Conclusion from http://en.wikipedia.org/wiki/Government_incentives_for_plug-in_electric_vehicles (accessed March 15, 2012) and ACEA (2011)

Note: For more details, please see Appendix B.

2.5 Related Research

2.5.1 Factors influencing HEV/eco car adoption

David Diamond (2006) used cross-sectional time-series data on new Hybrid Electric Vehicle (HEV) registrations in different U.S. states in 2003 and 2004 to evaluate the effect of tax incentives, gasoline prices and other socio-economic factors on the demand for Hybrid Electric Vehicles (HEVs) in different U.S. states.

Pathumwan Nambutr (2008) investigated the factors influencing on decision making to buy hybrid cars among people who could drive and usually commute to Bangkok. The study gathered data by questionnaire distributing to 100 respondents (accidental sampling method) and used SPSS program to analyze data. Among the marketing mix activities of HEV, fuel consumption and emission rates have most influence on the respondents' buying decision. The most personal and situational influences are related to fuel issues whereas the most social influence related to environmental consciousness. This study asked respondent to give suggestions about factor promoting HEV usage in Thailand and the majority recommended government to lower import tax.

Gallagher and Muehlegger (2008) used consumer adoption of hybrid-electric vehicles (HEV) in the United States from 2000-2006 and a fixed effect panel regression to examine the factors related to consumer adoption of HEVs consisting of sales tax waivers, income tax credits, changing gasoline prices, and consumer preferences for environmental quality or energy security. These factors are associated with 6, 27 and 36 percent of hybrid sales from 2000-2006 respectively. Moreover, they found that sales tax waivers impacted on increase in hybrid sales 7-time more powerful than income tax credits.

Tolba and Mourad (2008) studied about individual and cultural factors affecting diffusion of innovation. They found that innovations diffused slower in collectivist cultures than in individualistic cultures. Uncertainty Avoidance slowed down innovation acceptance and diffusion due to the inherent risk aversion in the society. Moreover, they examine a role of individual impacting on innovation. Lead users' role is critical to decrease complexity and increase relative advantage. They attract users to adopt the innovation; while opinion leaders are crucial to drive innovation diffusion across the chasm. Communicability is crucial to the innovation adoption process, as it incorporates the role of word-of-mouth through both lead users and opinion leaders, along with other interpersonal networks.

2.5.2 Bass Model

Lamberson (2008) compared the diffusion of HEVs to previous automotive innovations including minivan and airbag. The conclusion shows that HEV will still be the niche product and has a little chance for significant market penetration, if a single manufacturer dominates HEV sales analogously to minivans. On the other hand, HEV innovation is unlike the minivan innovation in view of technology. Hybrid technology is only an addition to current vehicles, like airbag. Airbag has a much slower initial diffusion because of its price premium. But its sales were a significant shift because of a federal regulation about passive restraint. If HEVs followed a similar adoption path to airbags, hybrid technology will ultimately penetrate the entire vehicle market. He also used Bass and Gompertz diffusion models applied to current HEV adoption data and extrapolate so as to forecast the trend of hybrid adoption in the future. The Gompertz

model forecasts higher future growth rates than the Bass model and it is more consistent with industry expectations.

McManus and Senter (2009) were sponsored by U.S. Department of Energy to study about technical challenges of plug-in hybrid electric vehicles and impacts to the U.S. power system. They predicted Plug-In Hybrid Electric Vehicles (PHEV) adoption by examining benchmark market models with fixed saturation levels including Bass model, Generalized Bass Model, Gompertz model and Logistic model. The adoption curves of the Bass and Logistic models are nearly coincident and the Generalized Bass model is only slightly different from the two previous models. Gompertz model has the similar result for first 9 years but after that the Gompertz cumulative adoptions curve rapidly diverges from the others.

CHAPTER 3 RESEARCH METHODOLOGY

This research uses fundamental analysis and Bass model as tools to study pattern of innovation diffusion.

3.1 Conceptual Framework

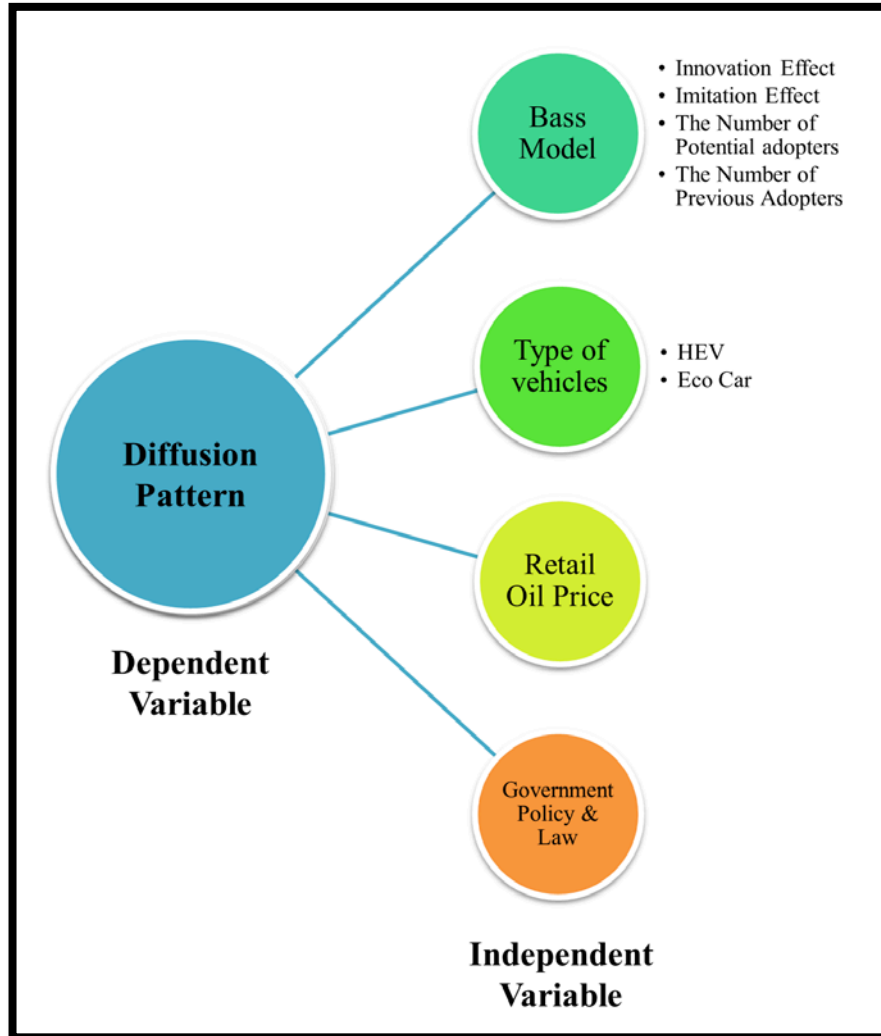


Figure 3.1 Conceptual Framework

From literature review, diffusion of innovation is depended on 4 factors.

- 1) The number of sales in each quarter which is function of innovation effect, imitation effect, the number of potential adopters and the number of previous adopters
- 2) Type of vehicles
- 3) Retail oil prices
- 4) Government policy and related law

3.2 Data

3.2.1 HEV

This research uses new registered vehicle data at the state-quarter level obtained mainly from Transport Statistics Sub-Division, Planning Division, and Department of Land Transport as a proxy of sales to analyze by statistical analysis method as well as estimate a diffusion model. The data covered the period January, 2007 – December, 2012. The main data used in this study are shown in the Appendix C.

3.2.2 Eco Car

This research uses annually new registered vehicle data classified by Brand and engine capacity from Transport Statistics Sub-Division, Planning Division, and Department of Land Transport as a proxy of sales to be analyzed by statistical analysis method and estimated a diffusion model. The data covered the period April 2011 – March 2013. The main data used in this study are shown in the Appendix D.

3.3 Data Analysis

In this research, data were analyzed by Microsoft Excel 2010 and presented into fundamental mathematic formula such as percentage and growth.

3.3.1 Percentage

$$P = \frac{n}{N} \times 100$$

Meaning of the symbols

P = Percentage of n relative to N

n = The number of subset (Part)

N = The number of full set (Whole)

3.3.2 Percent Change

$$\Delta P = \frac{N(t) - N(t-1)}{N(t-1)} \times 100$$

Meaning of the symbols

ΔP = Percentage change

N(t) = Value of N at period t

N(t-1) = Value of N at period t-1

3.4 Bass Model

From the aforementioned concept of Bass model in chapter 2, the equation must be altered into proper form to be used for solving its parameter.

$$L(t) = \frac{f(t)}{[1 - F(t)]} \quad \text{-- (1)}$$

$$L(t) = p + \left(\frac{q}{m}\right)N(t) \quad \text{-- (2)}$$

Equating (1) and (2) :

$$\frac{f(t)}{[1 - F(t)]} = p + \left(\frac{q}{m}\right)N(t) \quad \text{-- (3)}$$

Rearrange the equation

$$f(t) = \left\{p + \left(\frac{q}{m}\right)N(t)\right\}[1 - F(t)] \quad \text{-- (4)}$$

Defining the number of adopters at particular time t as $n(t)$ ($f(t) = n(t)/m$) and total number of adopters up to time t as $N(t)$: ($F(t) = N(t)/m$)

$$n(t) = p(m - N(t)) + \left(\frac{q}{m}\right) N(t) (m - N(t)) \quad \text{-- (5)}$$

Both terms reflect type of diffusion (Innovator/Imitator) in their meaning as follows.

- " $p(m - N(t))$ " represents adopters who are not influenced by the number of people who have already bought the product in the timing of their adoption
- " $\left(\frac{q}{m}\right)N(t)(m - N(t))$ " represents adopters who are influenced by the number of previous buyers. (Mahajan et al., 1993)

Rearrange equation (5)

$$n(t) = pm + (q - p)N(t) - \left(\frac{q}{m}\right) N^2(t) \quad \text{-- (6)}$$

Define α_1 , α_2 , α_3 as following

$$\alpha_1 = pm$$

$$\alpha_2 = q - p$$

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

The equation (6) changes its form into

$$n(t) = \alpha_1 + \alpha_2 N(t) + \alpha_3 N^2(t) \quad \text{-- (7)}$$

3.5 Quadratic Formula

Obtaining coefficient by using regression technique, it is able to find p , q and m by using the quadratic formula.

Substitute p and q in the equation (8) with α_1 and α_3

$$\alpha_2 = -(\alpha_3 m) - \left(\frac{\alpha_1}{m}\right) \quad \text{-- (8)}$$

Multiply both side by m

$$\alpha_2 m = -(\alpha_3 m^2) - \alpha_1 \quad \text{-- (9)}$$

Rearrange the equation (8)

$$\alpha_3 m^2 + \alpha_2 m + \alpha_1 = 0 \quad \text{-- (10)}$$

Considering equation in a standard form $ax^2 + bx + c = 0$ with real or complex coefficient, there will be two solutions (roots) which may or may not be distinct as well as may or may not be real number.

$$ax^2 + bx + c = a \left(x - \frac{-b + \sqrt{b^2 - 4ac}}{2a} \right) \left(x - \frac{-b - \sqrt{b^2 - 4ac}}{2a} \right)$$

$$0 = a \left(x - \frac{-b + \sqrt{b^2 - 4ac}}{2a} \right) \left(x - \frac{-b - \sqrt{b^2 - 4ac}}{2a} \right)$$

$$0 = \left(x - \frac{-b + \sqrt{b^2 - 4ac}}{2a} \right) \left(x - \frac{-b - \sqrt{b^2 - 4ac}}{2a} \right)$$

Thus, the roots are able to written in the form like this.

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

Using aforementioned quadratic equation, coefficients of Bass model such as p, q and m can be solved as follows.

Find m in term of α_1 , α_2 and α_3

$$m = \frac{-(\alpha_2) \pm \sqrt{(\alpha_2)^2 - 4(\alpha_1)(\alpha_3)}}{2(\alpha_3)} \quad \text{-- (11)}$$

Substitute m by $-\frac{q}{\alpha_3}$

$$-\frac{q}{\alpha_3} = \frac{-(\alpha_2) \pm \sqrt{(\alpha_2)^2 - 4(\alpha_1)(\alpha_3)}}{2(\alpha_3)} \quad \text{-- (12)}$$

Find q in term of α_1 , α_2 and α_3

$$q = \frac{(\alpha_2) \pm \sqrt{(\alpha_2)^2 - 4(\alpha_1)(\alpha_3)}}{2} \quad \text{-- (13)}$$

Substitute q by $\alpha_2 + p$

$$\alpha_2 + p = \frac{(\alpha_2) \pm \sqrt{(\alpha_2)^2 - 4(\alpha_1)(\alpha_3)}}{2} \quad \text{-- (14)}$$

Find p in term of α_1 , α_2 and α_3

$$p = \frac{(\alpha_2) \pm \sqrt{(\alpha_2)^2 - 4(\alpha_1)(\alpha_3)}}{2} - \alpha_2 \quad \text{-- (15)}$$

$$p = \frac{(\alpha_2) \pm \sqrt{(\alpha_2)^2 - 4(\alpha_1)(\alpha_3)}}{2} - \frac{2(\alpha_2)}{2} \quad \text{-- (16)}$$

$$p = \frac{-(\alpha_2) \pm \sqrt{(\alpha_2)^2 - 4(\alpha_1)(\alpha_3)}}{2} \quad \text{-- (17)}$$

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)

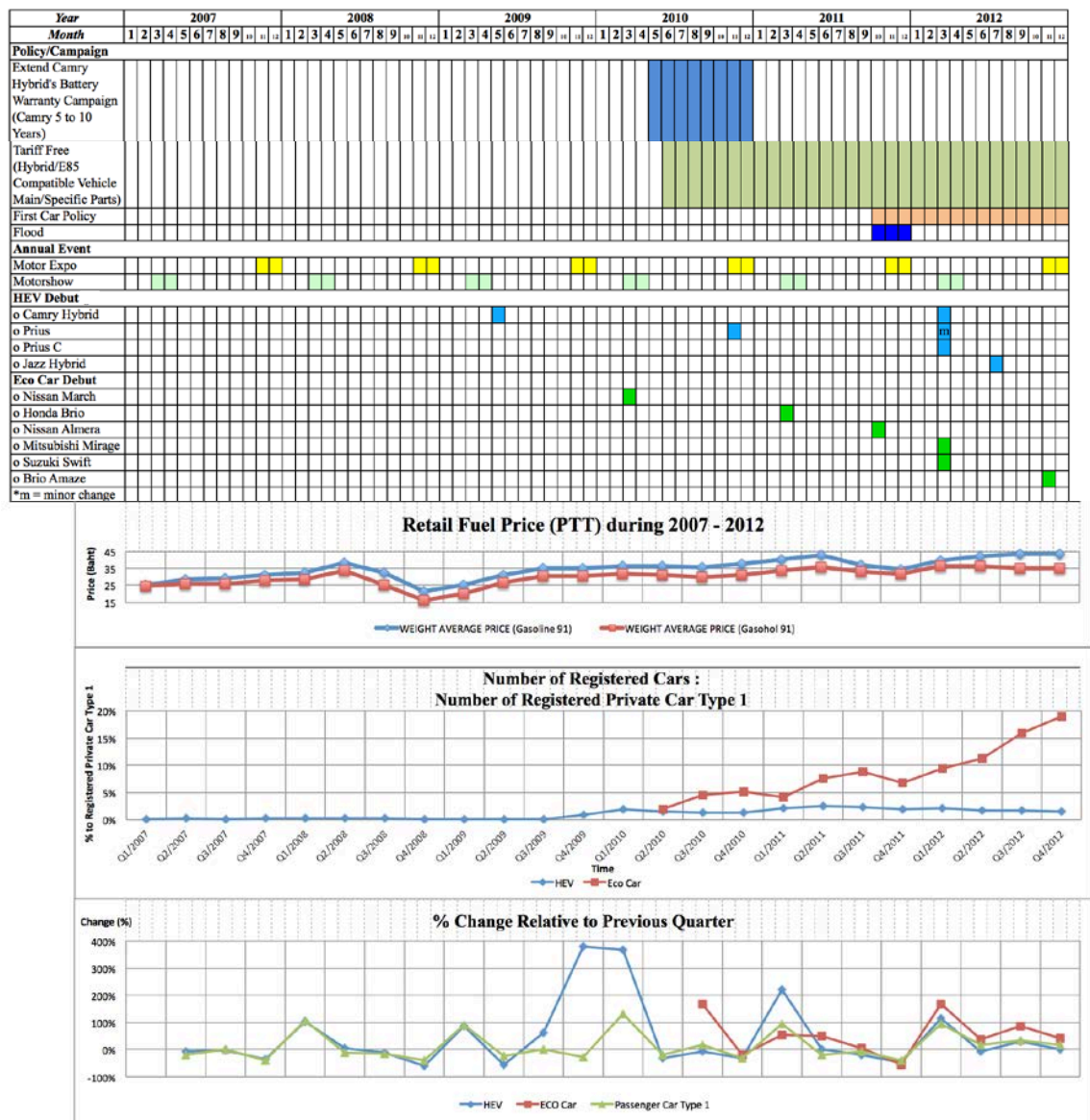


Figure 4.1 Timeline of HEV and Eco Car

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.

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

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

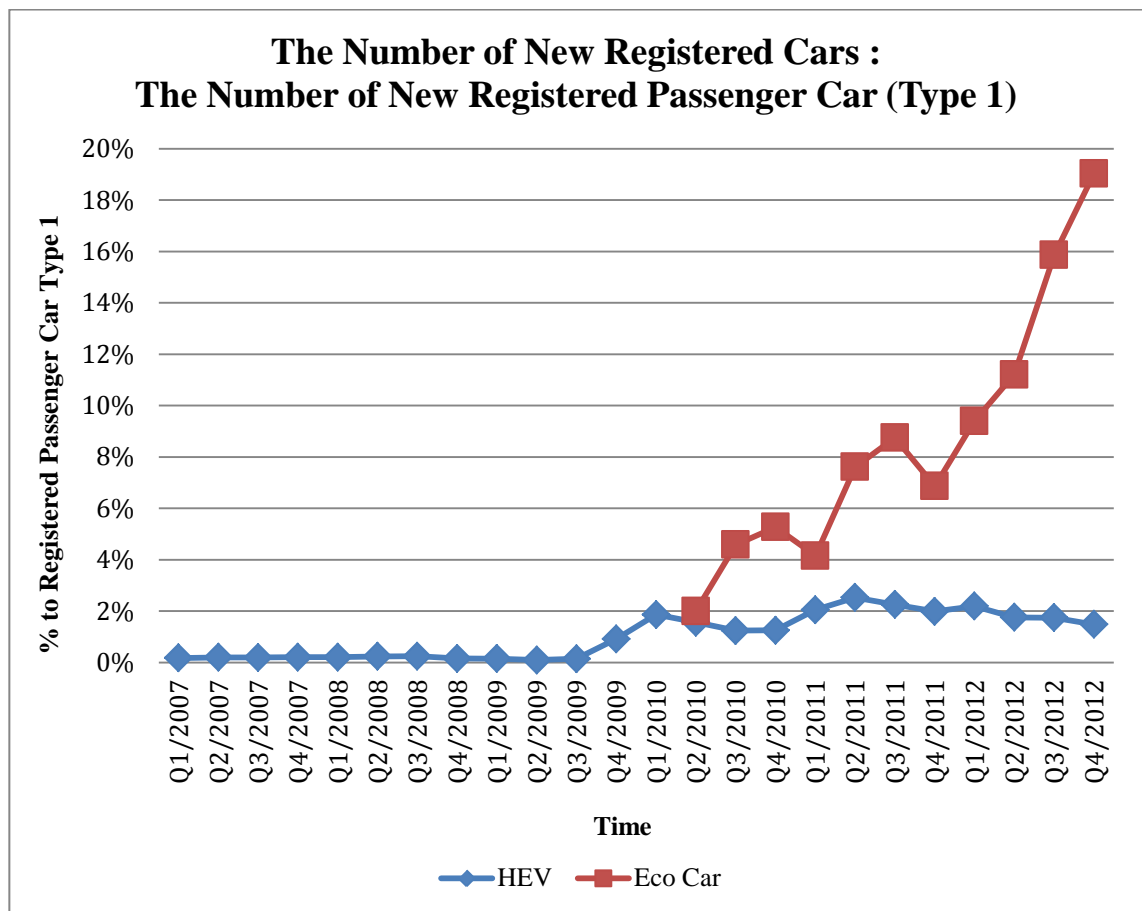


Figure 4.2 Ratios of New Registered Vehicles

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.

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

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

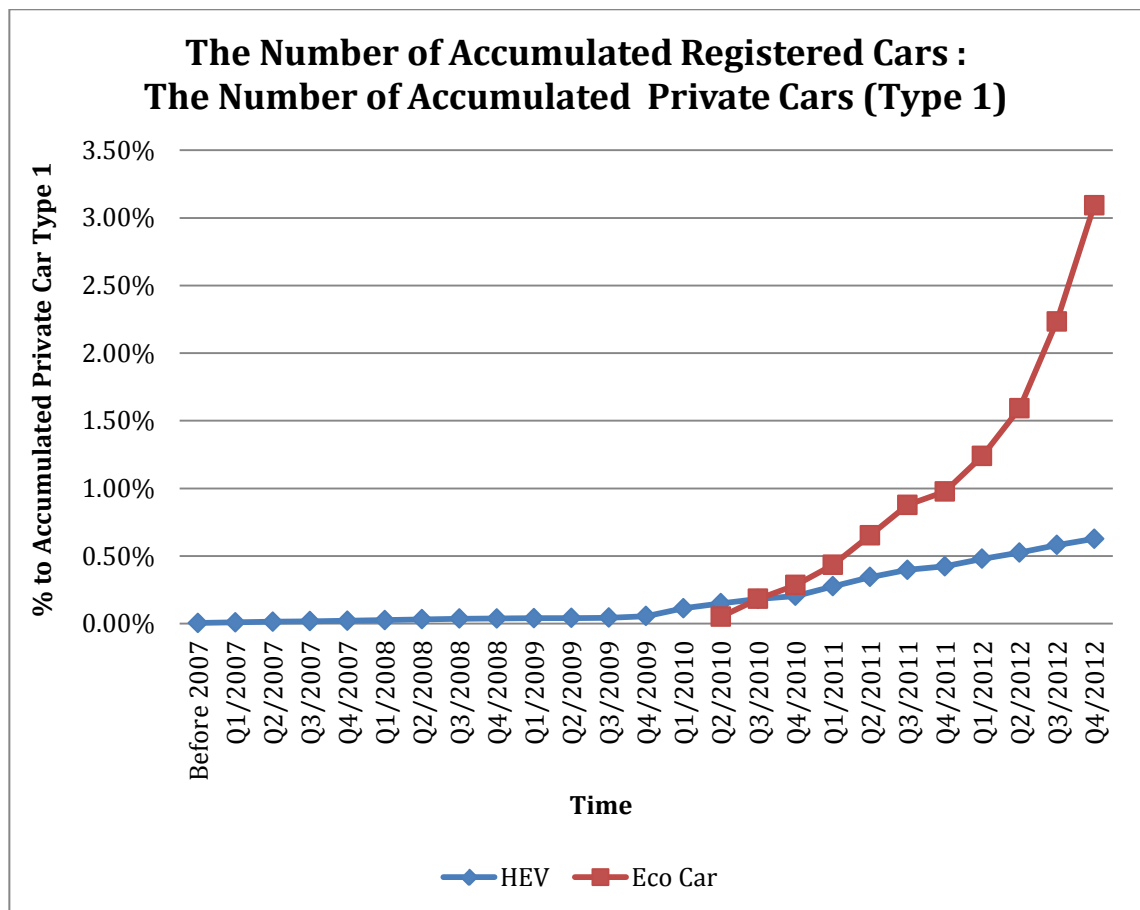


Figure 4.3 Ratios of Accumulated Registered Vehicles

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 CO₂ 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 3 rd 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)

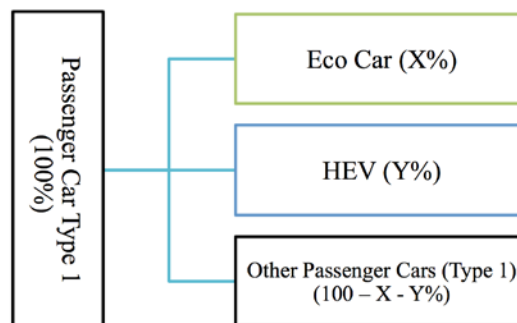
**Figure 4.4** Buying Decision

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.

$\% \Delta$ new registered HEVs =

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

$\% \Delta$ new registered eco cars =

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

$\% \Delta$ new registered passenger cars (Type 1) =

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

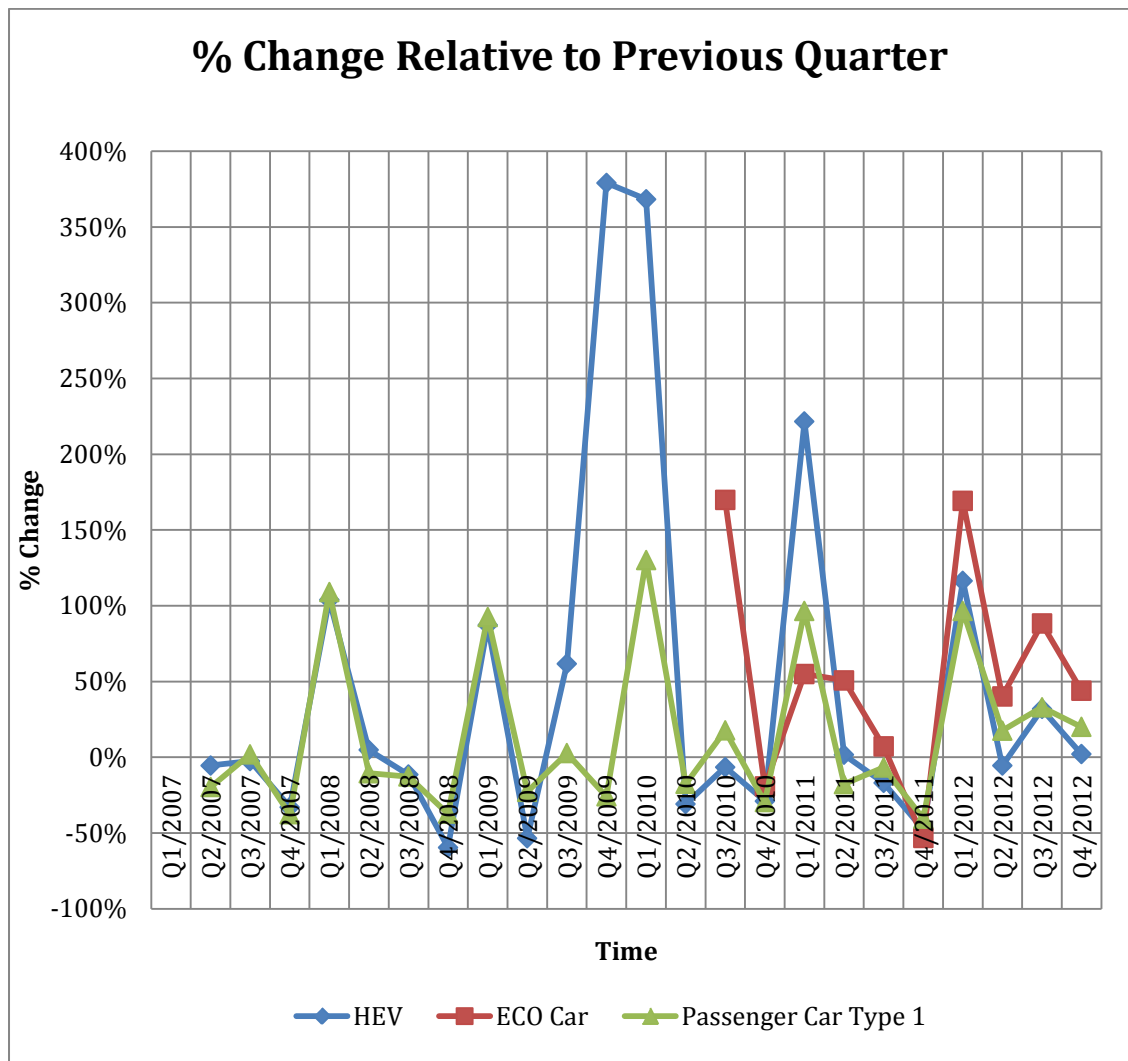


Figure 4.5 % Change Relative to Previous Quarter

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)	$\Delta(1)$	$\Delta(2)$	$\Delta(3)$
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, % Δ new registered HEV and % Δ new registered eco car should conform to % Δ new registered passenger car (Type 1). However, there are some periods that they

are disparate.

In Q4/2009, % Δ new registered HEV was 379.09% while % Δ 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, % Δ new registered HEV was -5.6% while % Δ 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 % Δ 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.

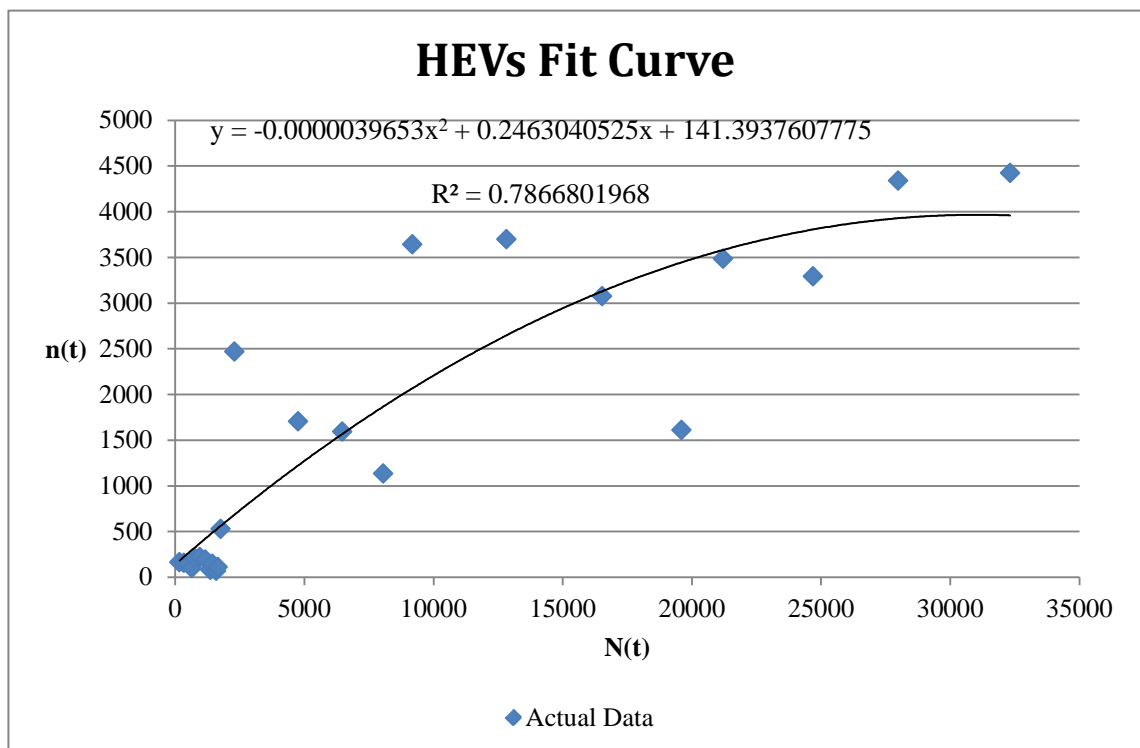


Figure 4.6 HEVs Fit Curve

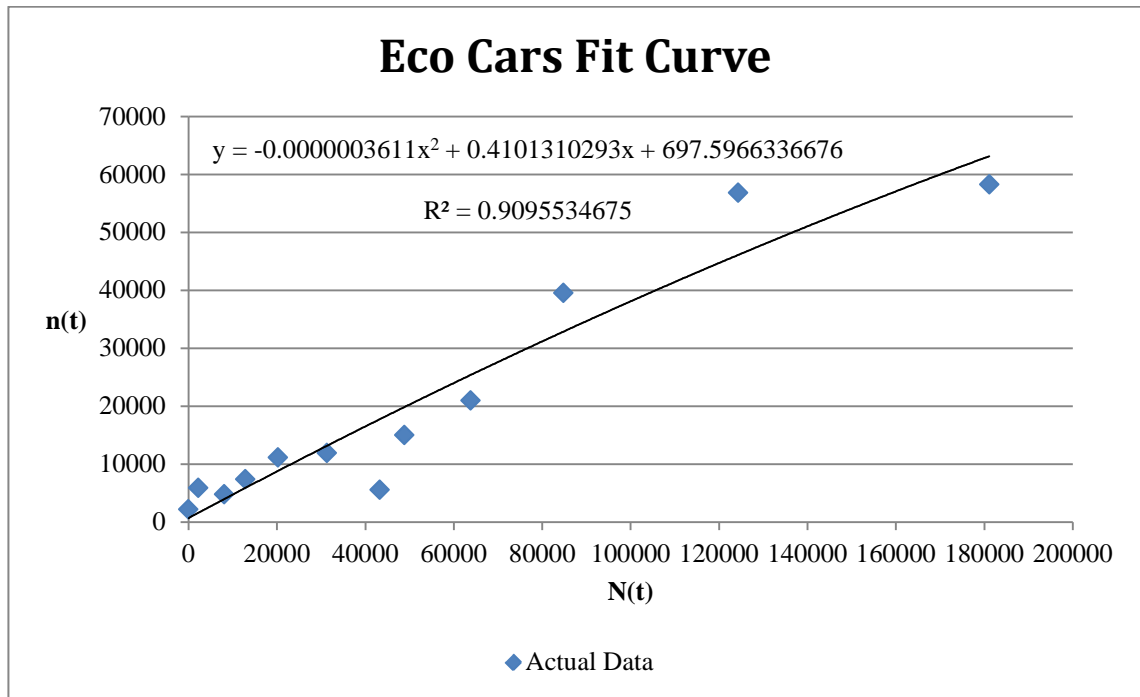


Figure 4.7 Eco Cars Fit Curve

4.2.1 Bass Model Coefficients for HEV

Substitute α_1 , α_2 , α_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 α_1 , α_2 , α_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 α_1 , α_2 , α_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)

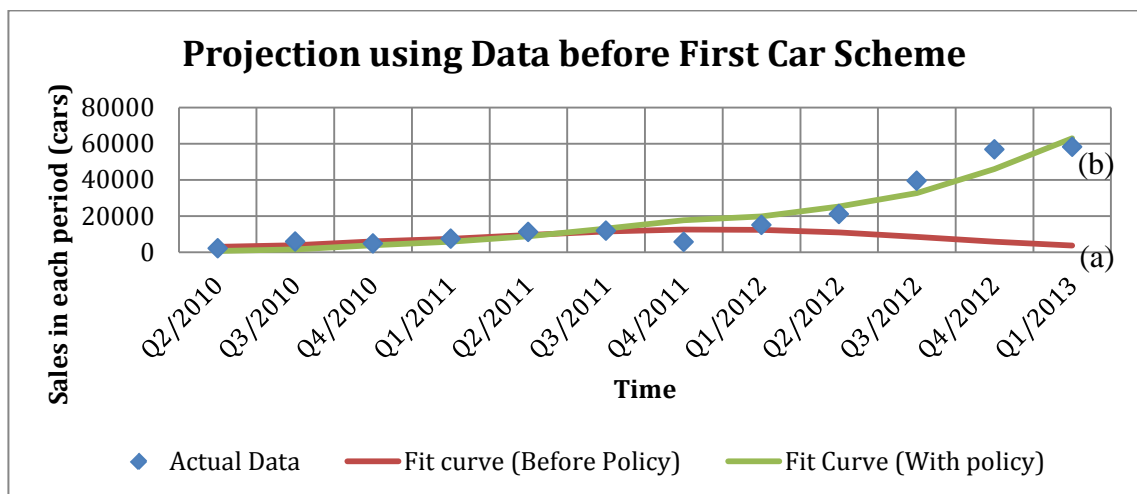
Parameter	Positive Root	Negative Root
p	0.000613347	-0.410744376
q	0.410744376	-0.000613347
m	1137360.99	-1698.371723

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).

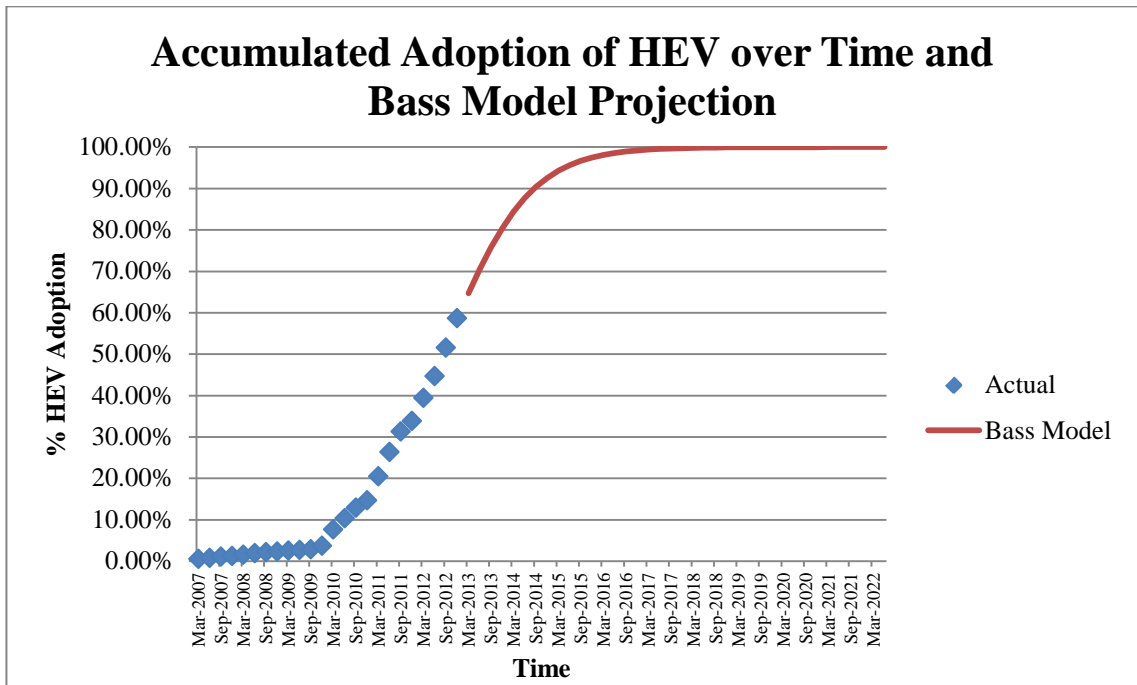


Figure 4.9 Accumulated Adoption of HEV and Bass Model Projection

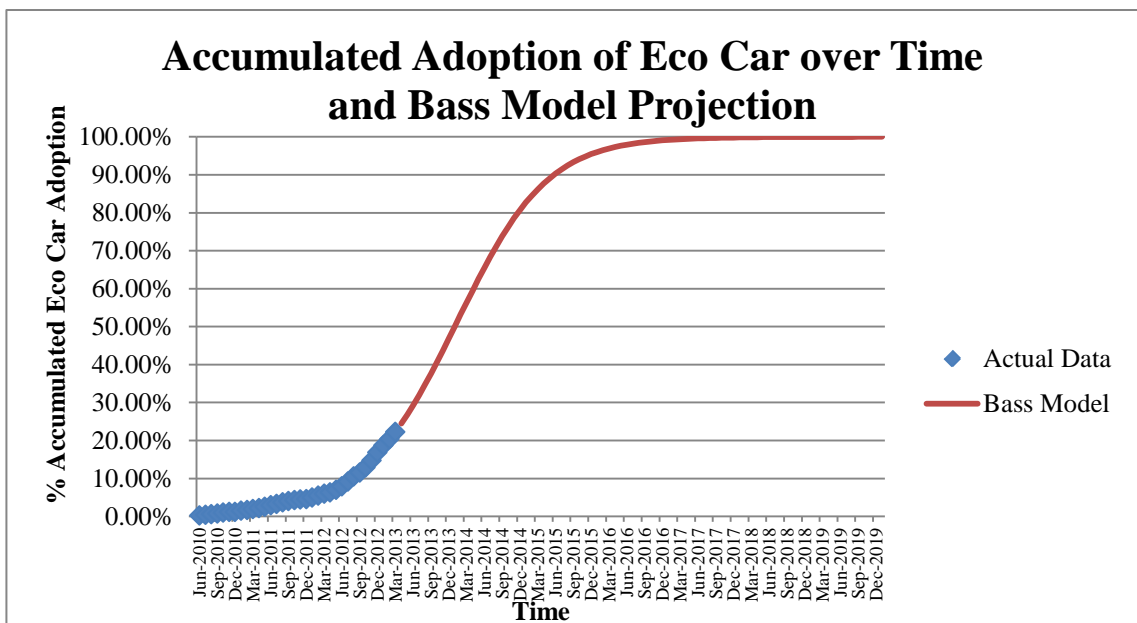


Figure 4.10 Accumulated Adoption of Eco Car and Bass Model Projection

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.

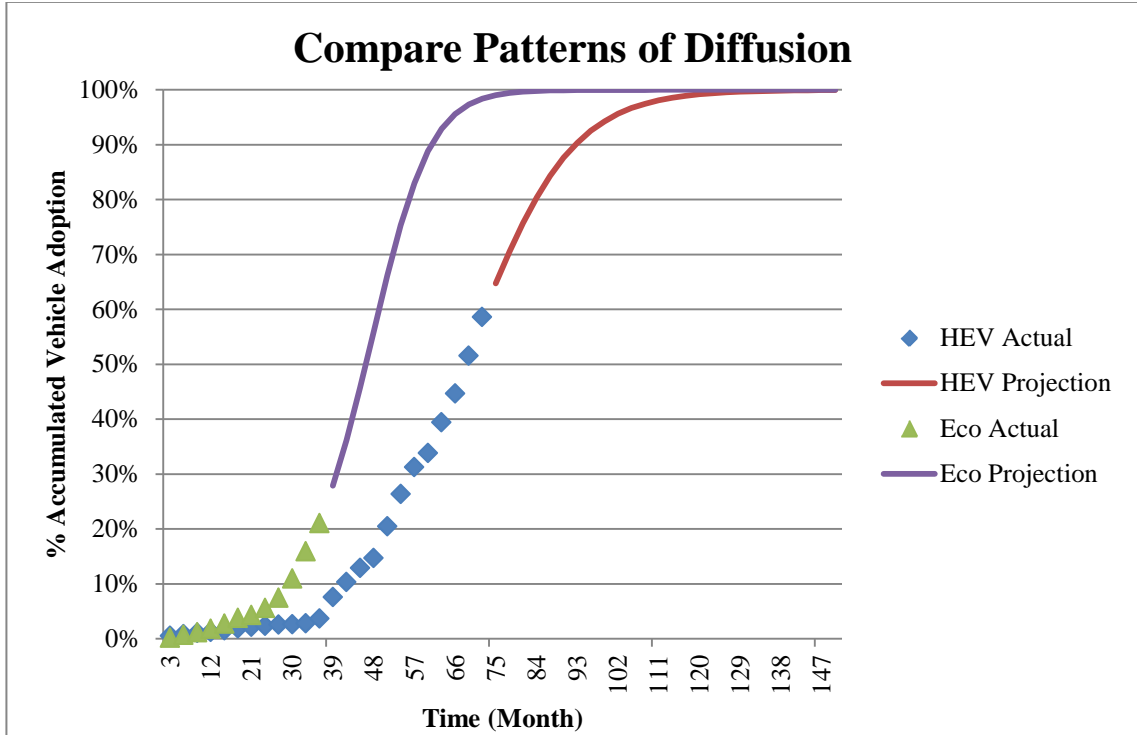


Figure 4.11 Comparisons of HEV and Eco Car Diffusions (%)

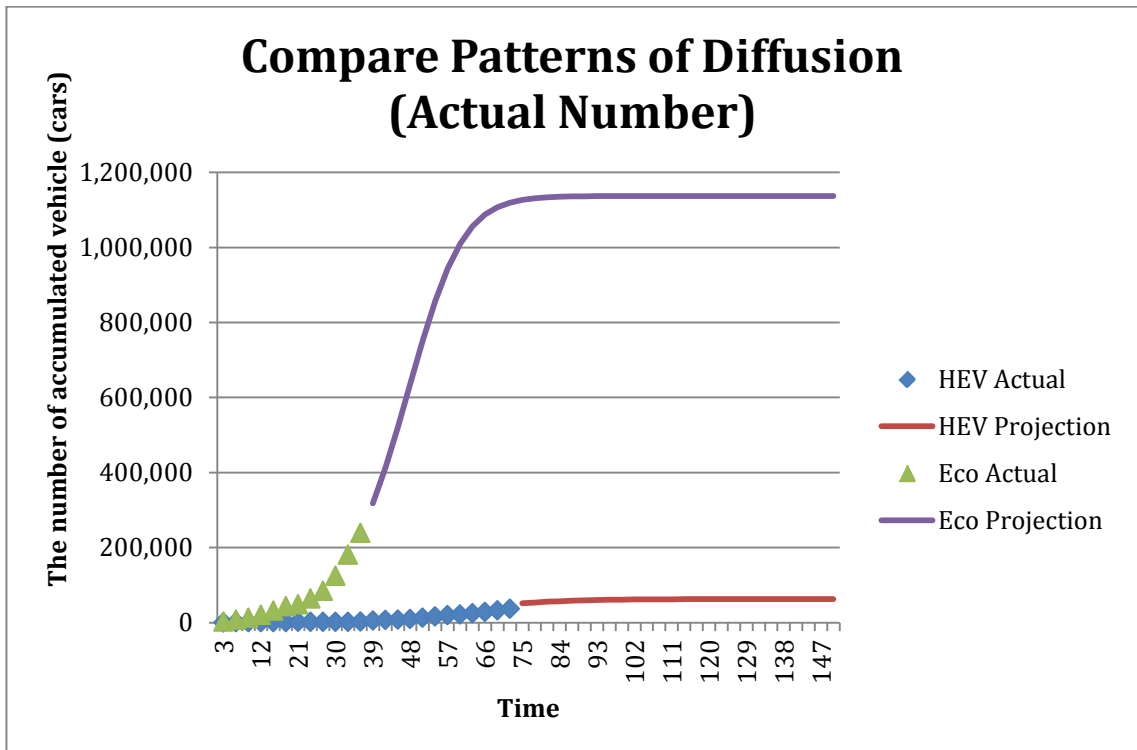


Figure 4.12 Comparisons of HEV and Eco Car Diffusions (Actual Number)

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 t₀ 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	<ul style="list-style-type: none"> • Time 	<ul style="list-style-type: none"> • Time • Predetermined budget • The number of qualified applicants
2. Condition (Vehicle)	<ul style="list-style-type: none"> • Price • Cylinder capacity • Manufacturer’s origin 	<ul style="list-style-type: none"> • Type of vehicles • Fuel economy • CO₂ emission
3. Condition (Buyer)	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • Fixed 	<ul style="list-style-type: none"> • 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 CO₂ 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%)	<i>Nissan</i>	<i>March</i>	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
		<i>Almera</i>	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
	<i>Honda</i>	<i>Brio</i>	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
		<i>Brio Amaze</i>	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	
	<i>Suzuki</i>	<i>Swift</i>	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
	<i>Mitsubishi</i>	<i>Mirage</i>	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)	<i>Toyota</i>	<i>Vios</i>	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
		<i>Yaris</i>	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
	<i>Mazda</i>	<i>Mazda 2</i>	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
	<i>Honda</i>	<i>City</i>	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
		<i>City CNG</i>	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
		<i>Jazz</i>	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)	<i>KIA</i>	<i>Picanto</i>	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	
			<i>Rio</i>	Starting Price	1.4 Automatic	2011	1,396/107	749,000	100,000	649,000
	<i>Ford</i>	<i>Fiesta 299</i>	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	
	<i>Chevrolet</i>	<i>Aveo</i>	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	
		<i>Sonic</i>	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	
	<i>DFSK</i>	<i>V27</i>	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%)	<i>Honda</i>	<i>Jazz Hybrid</i>	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.

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

$$\text{- Interior tax} = \text{Excise Tax} \times 0.1$$

$$\text{- VAT} = (\text{Factory Price} + \text{Excise Tax} + \text{Interior Tax} + \text{Profit}) \times 0.07$$

$$\text{- Imported Duty} = (\text{Cost} + \text{Insurance} + \text{Freight}) \times 0.8$$

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 CO₂ 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 CO₂ 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 CO₂ 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
	151 - 200 g/km	35	30	25							
	> 200 g/km	40	35	30							
	> 3,000	50					> 3,000		50		
Pickup Passenger Vehicle	<= 3,250	3					<= 3,250	<= 200 g/km	3		
		50						> 200 g/km	5		
> 3,250	50					> 3,250	50				
	<= 3,250	3						<= 3,250	<= 200 g/km	5	
50					> 3,250	> 200 g/km			7		
> 3,250	50						> 3,250	50			
	<= 3,250	12							<= 3,250	<= 200 g/km	12
50					> 3,250	> 200 g/km	15				
> 3,250	50						> 3,250	50			
	<= 3,250	20							<= 3,250	<= 200 g/km	25
50					> 3,250	> 200 g/km	30				
> 3,250	50						> 3,250	50			
	Gasoline <= 1,300 Diesel <= 1,400	17							Gasoline <= 1,300 Diesel <= 1,400	<= 100 g/km	14
					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 CO₂ 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, CO₂ 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 CO₂ 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.

CHAPTER 5 CONCLUSION

This chapter presents a summary of the findings in the comparative study of HEV and eco car diffusion in Thailand and recommendations for further research.

5.1 Summary of the Research

5.1.1 Objectives of the Study

The objectives of the research were to find out similarities and differences of diffusion pattern of HEV and eco car in Thailand and to suggest government policies which are able to encourage their adoptions.

5.1.2 Data and Procedures

The statistical data used in this study obtained from Transport Statistics Sub-Division, Planning Division, and Department of Land Transport. The number of new registered vehicle was used as a proxy for sales. The HEVs' data covered the period during January, 2007 – March, 2013 while the eco cars' data covered the period during April 2011 – March 2013.

The methodology used in this research can be classified into 3 sections.

1. Mathematics

1) Percent of new registered vehicles: to find ratio of HEV/eco car sales to passenger car (type 1) sales in each quarter

2) Percent of accumulated registered vehicles: to find ratio of HEV/eco car on roads to passenger car (type 1) on roads

3) Percent change of the number of new registered: to find growth patterns of HEV and eco car sales relative to growth of passenger car (type 1) sales

2. Bass model

1) Use statistical data to find fit curve so as to solve for Bass model equation

2) Use quadratic formula to solve for p , q , m

3) Use all the parameter to predict HEV and eco car sales

3. Government policy analysis and comparison with foreign government policy

5.2 Conclusion

The ratio of new registered HEVs to new registered passenger car (type 1) fell down during Q4/2008 and Q2/2009 (from 0.24% in Q3/2008 to 0.09% in Q2/2009) which was the period that retail oil price went down. This implied that low oil price made HEV less attractive. After that the ratio and the oil price went up altogether. The ratio fluctuated in a small gap (1.24 – 2.53%) in last 3 years. The main factor made this ratio increased is to put new products on sales, especially Camry Hybrid and Prius. The Camry was introduced into market in Q2/2009 and made the ratio grown up rapidly from 0.09% to 0.15% in Q3/2009, 0.91% in Q4/2009 and 1.86% in Q1/2010.

This situation happened when Prius generation 3 was debuted in Q4/2010 and the ratio grew from 1.25% to 2.05% in Q1/2011 and 2.53% in Q2/2011. However, this situation did not occur when Prius with minor change, Prius C and all new Camry Hybrid was introduced in Q1/2012. It made the sales increase but not enough to gain more ratio of market share of passenger car (type 1).

The ratio of new registered eco cars to new registered passenger car (type 1) has grown up continuously (except Q1/2011) since the first eco car, Nissan March, was introduced to market. In Q4/2011, the ratio reduced from 8.75% to 6.87% due to flooding. After that the ratio increased dramatically in every quarter whether there is new car debut. This implied that the first car scheme (financial incentive) can encourage the vehicle adoption. The ratio from latest data (Q4/2012) was 19.3%.

The percent of accumulated registered vehicles in each quarter is the good index to show the ratio LEVs (HEVs and eco cars) on the road relative to other passenger cars type 1. The ratio shows the good signal that the ratio of LEVs gradually increases. The ratios from latest data (Q4/2012) were 0.63% in case of HEV and 3.69% in case of eco car.

The percent change of the number of new registered vehicles relative to previous quarter shows pattern of change. Normally, $\% \Delta$ new registered HEV and $\% \Delta$ new registered eco car should conform to $\% \Delta$ new registered passenger car (Type 1). However, there are some periods that they are distinct disparities especially in case of HEV. In Q4/2009, $\% \Delta$ new registered HEV was 379.09% while $\% \Delta$ new registered passenger car (Type 1) was -25.87%. This is the consequence of placing Prius Generation 3 on sales.

Using mathematics, the results show that the factors influenced on HEV adoption were oil price and new products on sales while the factors influenced eco car adoption were new products on sales and financial incentive such as the first car scheme. These results were also obtained when analyzed the data which significantly deviated from the fit curve (Bass model equation).

Based on assumption of Bass model that HEV and eco car are the durable products which once are adopted and not repurchased for many years, the result shows that p of HEV (0.00225568) is 3.68 times greater than which of eco car (0.000613347). On the contrary, q of eco car (0.410744376) is 1.65 times greater than which of HEV (0.248559732).

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. The saturation point without continuous repeat purchasing of eco car (~1,137,361) is 18 times greater than which of HEV (~62,683). This is why the number of first adopters (innovators) at time period 1 (which equal to mp) of eco cars more than which of HEVs. This can be described by using five attributes influencing on rate of adoption. Eco car has more relative advantage, compatibility but less complexity than HEV because eco car is only downsizing vehicle with additional standards while HEV is more expensive vehicle with advance technology.

Using the Bass model equations, the projected result shows that HEV sales passed the peak whereas sales of eco car will reach its peak in a half year. Thus, if Bass model parameters (p , q , m) remain the same, HEV sales trend is downturn while eco car sales trend will continue to grow up for a half 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 so as to get them ready for the near future.

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 such as tax exemption/reduction/rebate/deduction and other privilege with monetary value.
- 2) Non-financial incentives by giving some privileges which do not have monetary value such as special lanes and car pool lane usage regardless of the number of passenger.
- 3) Financial disincentives for other vehicles (“Polluter Pays” principle)

However, due to the limitation of law and facilities, only financial incentives and financial disincentives are recommended to be used. Researcher suggests 3 rectified policies/laws.

The first one is tax rebate. If the government has a plan to encourage adoption of fuel efficient vehicles in the future, type of vehicles, fuel economy and CO₂ emission are recommended to use as criteria.

The second one is new excise tax structure. This section of act still based on the present excise tax structure based on engine size on the assumption that larger engines use more fuel. With new technologies, the theory may no longer true because some large engines are more fuel-efficient and emit less CO₂ than smaller ones. Thus, it is better to exclude cylinder capacity from criteria or to include CO₂ emission band in the largest size of each vehicle type so as to make manufacturer of such vehicles concern with CO₂ emission.

The third one is vehicle license tax (annual circulation tax). This law has been enforced since 1979 and has never been revised. Thus, to make this law efficiently to reduce carbon dioxide emission rates, CO₂ 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 CO₂ emissions.

5.3 Recommendations for Further Research

1) In the future, many advance vehicles like PHEV and BEV may be adopted in Thailand. It is recommended for other researchers to use Bass model to predict their adoption by using historical HEV data so as to make guideline for both government and vehicle manufacturers.

2) Each government policy has different impact on adopters. Thus, it is interesting to use survey study so as to find the most effective policy that encourages HEV and eco car diffusion.

3) Government normally uses both demand-push and supply-pull policies to encourage sales of specific vehicle. This research focuses only on demand side so the researcher would like to recommend those who are interested to further study the policies for the supply side.

4) The next research could use the result obtained from this research with the projective equation of adoption of all types of vehicle to make more proper policy.

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APPENDIX

**APPENDIX A.
PTT RETAIL OIL PRICE**

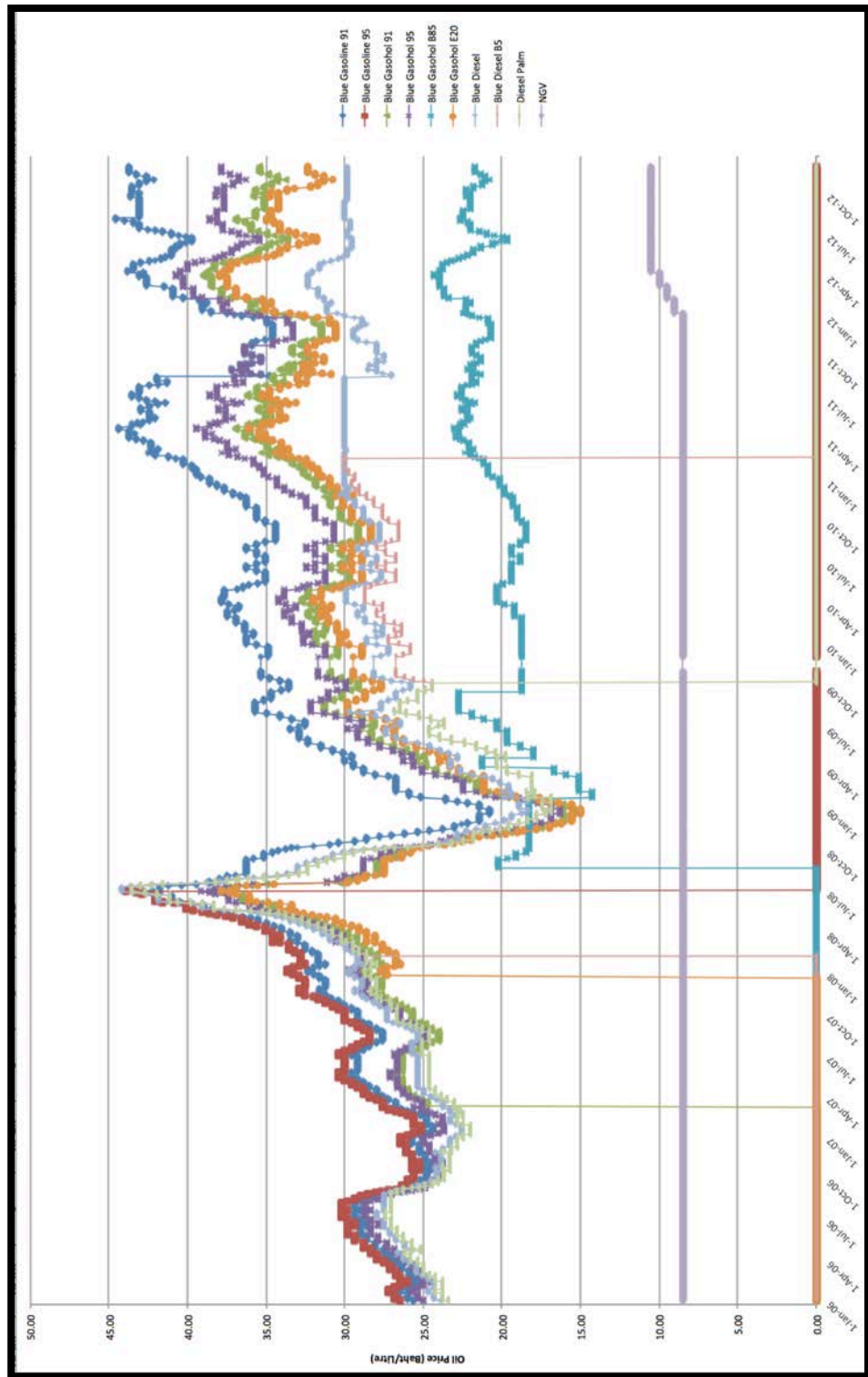


Figure A.1 PTT Oil Price in Bangkok and Metropolitan Area during 2006 - 2012

APPENDIX B.
TAX INCENTIVES FOR BEV, HEV AND PHEV IN THE EU

Table B.1 Tax Incentives for BEV, HEV AND PHEV in the EU

COUNTRY	INCENTIVE
AUSTRIA	<p>Electric vehicles are exempt from the fuel consumption tax and from the monthly vehicle tax.</p> <p>Private persons who purchase a passenger car that is powered exclusively by an electric motor receive a personal income tax reduction of 30% of the purchase price (with a maximum of € 9,190).</p> <p>Hybrid vehicles and other alternative fuel vehicles benefit from an additional bonus under the fuel consumption tax. This fuel consumption tax (Normverbrauchsabsage or NoVA) is levied upon the first registration of a passenger car. Under a bonus-malus system, cars emitting less than 120g/km receive a maximum bonus of €300. Alternative fuel vehicles including hybrid vehicles attract an additional bonus of maximum €500. This bonus regime is valid from 1 July 2008 until 31 August 2012.</p> <p>The Austrian automobile club ÖAMTC publishes the incentives granted by local authorities on its website (www.oeamtc.at/elektrofahrzeuge).</p>
BELGIUM	<p>Vehicles that do not qualify for the 30% income tax reduction may benefit from federal purchase incentives (15% of the purchase price with a maximum of €4,640 for cars emitting less than 105 g/km of CO₂ and 3% of the purchase price with a maximum of € 870 for cars emitting between 105 and 115 g/km of CO₂) and the Eco-bonus in Wallonia (€600 for cars with a list price of maximum €30,000 and emitting less than 99 g/km).</p> <p>Electric vehicles pay the lowest rate of tax under the registration tax (€61.50) and under the annual circulation tax (€71.28).</p> <p>The deductibility rate for expenses related to the purchase and use of company cars is 120% for zero- emissions vehicles and 100% for vehicles emitting between 1 and 60 g/km of CO₂. Above 60 g/km, the deductibility rate decreases gradually from 90% to 50%.</p> <p>The benefit in kind for the private use of a zero-emissions vehicle as a company car is taxed at the lowest rate (€500 – 750).</p>
CZECH REPUBLIC	<p>Electric, hybrid and other alternative fuel vehicles are exempt from the road tax (this tax applies to cars used for business purposes only).</p>
DENMARK	<p>Electric vehicles weighing less than 2,000 kg are exempt from the registration tax. This exemption does not apply to hybrid vehicles.</p>

Source: European Automobile Manufacturers' Association (2011)

Table B.1 Tax Incentives for BEV, HEV AND PHEV in the EU (Continued)

COUNTRY	INCENTIVE
SPAIN	Various regional governments (Aragon, Asturias, Baleares, Madrid, Navarra, Valencia, Castilla la Mancha, Murcia, Castilla y León, Cantabria, Catalunya, Galicia, Pais Vasco, Extremadura) grant incentives of €2,000 to €7,000 for the purchase of electric, hybrid, fuel cell, CNG and LPG vehicles. In Andalusia, the incentive is maximum 70% of the investment.
FRANCE	Vehicles emitting 60 g/km or less of CO ₂ benefit from a premium of maximum €5,000 under a bonus- malus scheme. For such vehicles, the amount of the incentive cannot exceed 20% of the vehicle purchase price including VAT, increased with the cost of the battery if this is rented.
	Hybrid vehicles emitting 110 g/km or less of CO ₂ benefit from a premium of €2,000. Electric and hybrid vehicles are exempt from the company car tax.
IRELAND	Electric vehicles are exempt from the registration tax VRT until 30 April 2011. From 1 May, they will benefit from VRT relief of maximum €5,000. Plug-in hybrids benefit from VRT relief of maximum €2,500 until 31 December 2012. Conventional hybrid vehicles and other flexible fuel vehicles benefit from VRT relief of maximum €1,500 until 31 December 2012.
ITALY	Electric vehicles are exempt from the annual circulation tax (ownership tax) for a period of five years from the date of their first registration. After this five-year period, they rate applied to equivalent petrol vehicles. benefit from a 75% reduction of the tax
LUXEMBOURG	Purchasers of electric vehicles (or other vehicles emitting 60 g/km or less of CO ₂) receive a premium of €3,000 (PRIME CAR-e) until 31 December 2011. The purchaser electricity from renewable energy sources in order to obtain the premium must have concluded an agreement to buy
NETHERLANDS	Electric vehicles are exempt from the registration tax BPM and from the annual circulation tax. Other vehicles including hybrid vehicles are also exempt from these taxes if less than 110 g/km (petrol) respectively. they emit less than 95 g/km (diesel) respectively.
PORTUGAL	Purchasers of electric vehicles receive a premium of €5,000 (limited to 5,000 vehicles). They receive an additional incentive of €1,500 if they have their old car scrapped simultaneously. Electric vehicles are exempt from the registration tax ISV and from the annual circulation tax. Hybrid vehicles benefit from a 50% reduction of the registration tax.

Source: European Automobile Manufacturers' Association (2011)

Table B.1 Tax Incentives for BEV, HEV AND PHEV in the EU (Continued)

ROMANIA	Electric and hybrid vehicles are exempt from the special pollution tax (registration tax).
SWEDEN	Electric vehicles with an energy consumption of 37 kWh per 100 km or less and hybrid vehicles with CO ₂ emissions of 120 g/km or less are exempt from the annual circulation tax for a period of five years from the date of their first registration. For electric and hybrid vehicles, the taxable value of the car for the purposes of calculating the benefit in kind of a company car under personal income tax is reduced by 40% compared with the corresponding or comparable petrol or diesel car. The maximum reduction of the taxable value is SEK 16,000 per year.
UNITED KINGDOM	Purchasers of electric vehicles and plug-in hybrid vehicles with CO ₂ emissions below 75 g/km receive a premium of £ 5,0000 (maximum) or 25% of the value of the vehicle provided they meet a series of eligibility criteria (for example, minimum range 70 miles for electric vehicles, 10 miles electric range for plug-in hybrid vehicles). More details on http://www.dft.gov.uk/pgr/sustainable/olev/grant1/ Electric vehicles are exempt from the annual circulation tax. This tax is based on CO ₂ emissions and all vehicles with emissions below 100 g/km are exempt from it. Electric cars are exempt from company car tax for a period of five years from the date of their first registration. Electric vans are exempt from the van benefit charge for a period of five years.
GERMANY	Electric vehicles are exempt from the annual circulation tax for a period of five years from the date of their first registration.
GREECE	Electric and hybrid vehicles are exempt from the registration tax.

Source: European Automobile Manufacturers' Association (2011)

APPENDIX C.
THE NUMBER OF NEW REGISTERED HEVs

Table C.1 The Number of New Registered HEVs During October, 2006 – December 31, 2012

Quarterly	New Registered HEV	New Registered Private Car Type 1
Before Q1/2007	168	
Q1/2007	165	97,674
Q2/2007	156	78,352
Q3/2007	152	79,856
Q4/2007	102	49,786
Q1/2008	208	104,074
Q2/2008	218	93,076
Q3/2008	193	81,202
Q4/2008	78	50,938
Q1/2009	146	98,066
Q2/2009	68	75,725
Q3/2009	110	77,736
Q4/2009	527	57,623
Q1/2010	2,468	132,590
Q2/2010	1,704	109,230
Q3/2010	1,592	128,542
Q4/2010	1,132	90,378
Q1/2011	3,640	177,585
Q2/2011	3,697	146,137
Q3/2011	3,074	136,270
Q4/2011	1,610	81,034
Q1/2012	3,485	159,272
Q2/2012	3,290	187,268
Q3/2012	4,337	248,990
Q4/2012	4,423	298,653
TOTAL	36,743	2,840,057

Source: Transportation Statistic Report Quarter 1 Fiscal Year 2550 - Quarter 1 Fiscal Year 2556 (Department of Land Transport)

APPENDIX D.
THE NUMBER OF NEW REGISTERED ECO CARS

Table D.1 The Number of New Registered Eco Cars during April 1, 2011 – March 31, 2013

	Honda	Mitsubishi	Nissan	Suzuki	SubTotal	Subtotal (Quarter)
Apr-10			157		157	2,185
May-10			608		608	
Jun-10			1,420		1,420	
Jul-10			2,157		2,157	5,895
Aug-10			1,990		1,990	
Sep-10			1,748		1,748	
Oct-10			2,177		2,177	4,761
Nov-10			1,779		1,779	
Dec-10			805		805	
Jan-11			2,857		2,857	7,379
Feb-11			2,079		2,079	
Mar-11			2,443		2,443	
Apr-11			2,647		2,647	11,123
May-11			3,823		3,823	
Jun-11	58		4,595		4,653	
Jul-11	591		3,557		4,148	11,922
Aug-11	810		3,536		4,346	
Sep-11	403		3,025		3,428	
Oct-11	189		2,188		2,377	5,565
Nov-11	128		1,739		1,867	
Dec-11	93		1,228		1,321	
Jan-12	337		4,508		4,845	14,977
Feb-12	203		4,729		4,932	
Mar-12	104		5,096		5,200	
Apr-12	67		4,198		4,265	20,992
May-12	801	69	6,405		7,275	
Jun-12	1,537	623	6,958	334	9,452	
Jul-12	2,544	2,129	8,340	1,113	14,126	39,504
Aug-12	2,261	3,322	6,950	1,338	13,871	
Sep-12	1,572	3,358	4,801	1,776	11,507	
Oct-12	1,610	4,456	6,124	2,287	14,477	
Nov-12	1,690	6,414	9,294	2,688	20,086	
Dec-12	1,401	7,432	10,468	2,967	22,268	

Source: Transport Statistic Sub-Division, Planning Division, Department of Land Transport (2013)

Table D.1 The Number of New Registered Eco Cars during April 1, 2011 – March 31, 2013 (Continued)

	Honda	Mitsubishi	Nissan	Suzuki	SubTotal	Subtotal (Quarter)
Jan-13	1,308	5,932	10,658	2,445	20,343	58,229
Feb-13	1,541	5,147	9,176	2,354	18,218	
Mar-13	2,531	6,016	8,445	2,676	19,668	
TOTAL	21,779	44,898	152,708	19,978	239,363	239,363

Source: Transport Statistic Sub-Division, Panning Division, Department of Land Transport (2013)

CURRICULUM VITAE

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HIGH SCHOOL	High School Graduation Triam Udom Suksa, 2002
BACHELOR'S DEGREE	Bachelor of Engineering (Computer Engineering) Chulalongkorn University, 2006
MASTER'S DEGREE	Master of Art (Labour Economics and Human Resource Management) Chulalongkorn University, 2007 Master of Business Administration (Entrepreneurship Management) King Mongkut's University of Technology Thonburi, 2012