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)

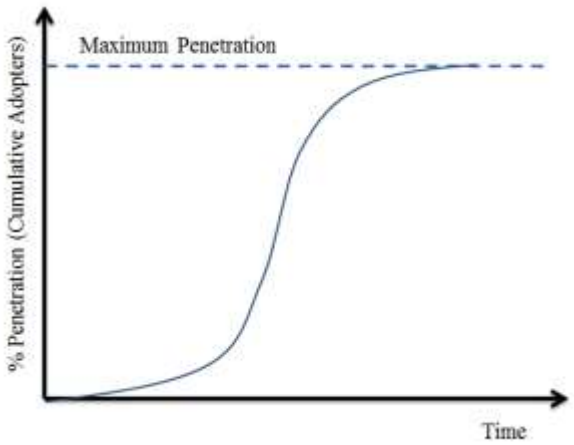


Figure 2.1 S-Curve

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)

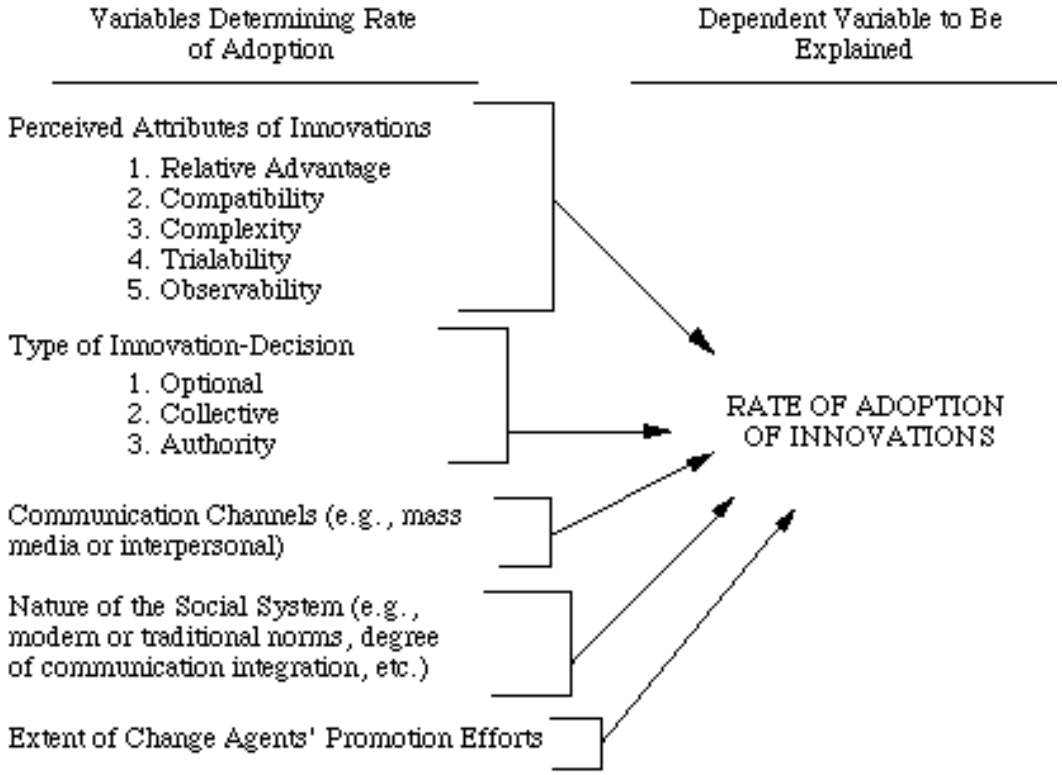


Figure 2.2 Variables Determining the Rate of Adoption of Innovations
Source: Rogers, (2003)

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

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

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) :

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

Rearrange the equation

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

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) = ($\frac{N(t)}{m}$))

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

"*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)

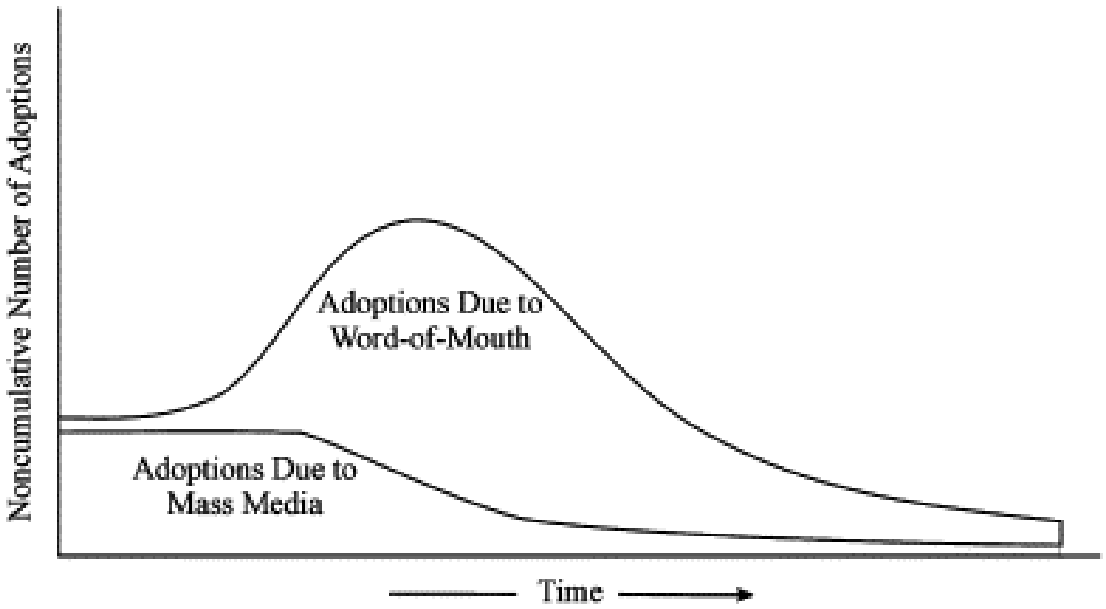
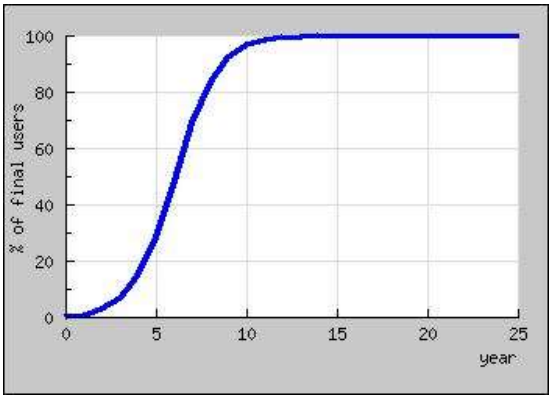


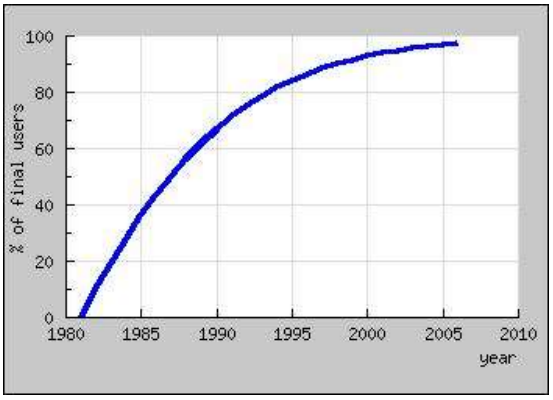
Figure 2.3 Innovators and Imitators
Source: J. Scott Armstrong (2001)

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.