A System Dynamic Hypothesis for the Disparate Alternative Fuel Vehicle Adoption Paths in Australia and the United States

Yimeng Jiang [a], David Keith [b], Matthew Doolan [a]

[a] Research School of Engineering, Australian National University, Acton, ACT 2601, Australia
[b] MIT Sloan School of Management, 77 Massachusetts Avenue, Cambridge, MA 02139, USA

yimeng.jiang@anu.edu.au; dkeith@MIT.EDU; matthew.doolan@anu.edu.au

Abstract

This paper presents a system dynamic hypothesis for the disparate Alternative Fuel Vehicle (AFV) adoption behaviour observed in Australia and the United States. Based on the Bass diffusion model, the paper incorporates consumer decision-making theories with system dynamic modelling to reveal the underlying dynamics rooted in individual adoption behaviour. Consumer adoption decision process literature identified the number and variety of models as crucial to the adoption of AFVs. As a necessary condition within the decision-making process, the number and variety of AFV models can limit the vehicle consumers' willingness for considering an AFV. The hypothesis presented depicts the growing rate of AFV adopters as the main driver to the growth of number and variety of AFV models. An approach to undertake the further work of testing the hypothesis is also discussed in this paper.

Keyword: Alternative fuel vehicle adoption, Innovation diffusion, Consumer-decision making process

1 Introduction

With increasing attention drawn to climate change and fossil fuel dependency, the promotion of alternative fuel vehicles (AFVs) that reduce GHG emissions and fuel usage has become a key transportation sustainability issue. Many countries have introduced AFVs into their vehicle markets, although the success of these introductions has been mixed.

In this paper we compare and contrast the cases of Australia and the United States, two countries that are similar in terms of high per capita vehicle ownership (The World Bank, 2011), road conditions defined by high traffic density in cities linked with long distance highways and a diverse range of vehicle models and manufacturers available (Federal Chamber of Automotive Industries, 2013, SelectUSA, 2013). While both countries saw the entrance of AFVs in the late '90s, with two major AFV technologies (hybrid-electric vehicles and clean diesel vehicles) penetrating into the market, the adoption paths of the two technologies are rather disparate. By the end of 2013, Australian diesel vehicles have grown to 7.07% of new passenger vehicle sales with hybrid- electric vehicles (HEVs) achieving only 1.05% of sales, while in the US, HEVs accounts for 3.12% of new passenger vehicle sales with diesel vehicles only achieving 0.87% of sales (Figure 1). Various studies have investigated AFV adoption in the past, but fail to explain the discrepancy of such market behaviour in the two countries. A comparison study that looks into two markets to understand the reasons behind different market behaviour has yet to be conducted.

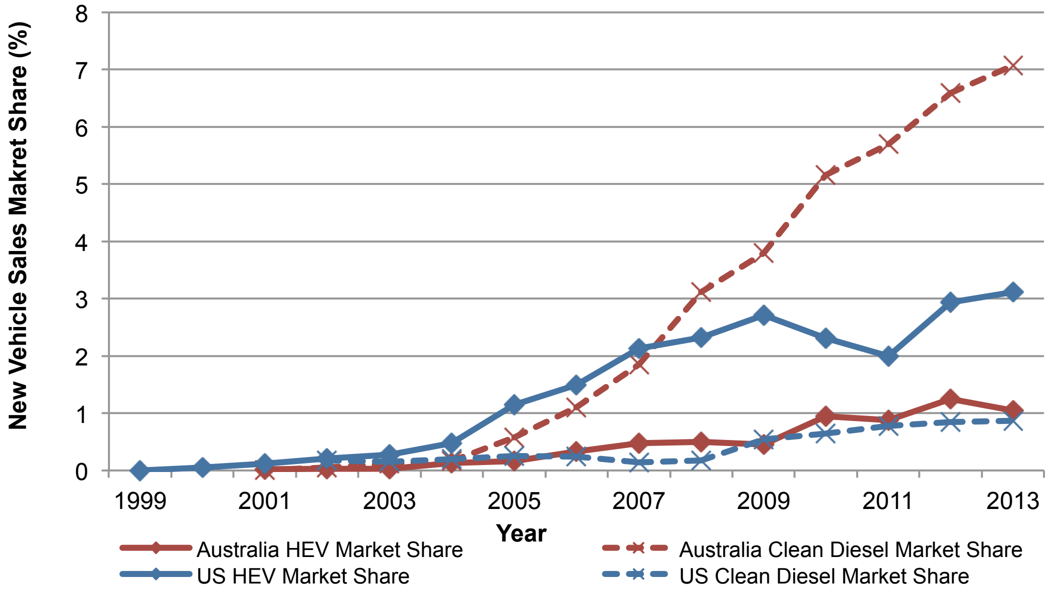

Figure 1 AFV adoption paths in Australia and the United States[1]

Based on the Bass diffusion model (Bass, 1969), this paper incorporates consumer decision-making process into system dynamic modelling to develop a hypothesis for mixed successes of AFV adoption in different markets as highlighted above. In the following sections, the paper first presents the influencing factors that have been identified in previous studies and their observed impact on adoption rate in Australia and the United States. From there, we consider consumer decision-making processes and their significance in understanding AFV adoption. A decision-making process on AFV adoption is proposed and the hypothesis that builds on it is presented. Finally, future work of testing the hypothesis is considered.

2 Background

AFV adoption has been studied by either using modelling techniques to simulate the system behaviour or by investigating the individual consumer behaviour when making an adoption decision. Studies that look into the consumer decision-making process identify the underlying components of the diffusion process and the reasons for the adoption behaviour. While studies using modelling discover the hidden dynamics behind various influencing factors and provide a clearer view of how the

---

[1] Data source: Australian Federal Chamber of Automotive Industries and Polk

social system reacts to the innovation. The influencing factors that are identified in the modelling studies help us to understand the change in the social system over time and the mechanism of innovation diffusion.

2.1 Influencing factors from AFV adoption literature

A significant amount of AFV adoption research takes different variables into accounts to address the impact of different influencing factors in the adoption process. The variables investigated in previous studies can be categorized into the following three groups: vehicle cost of ownership (Lee et al., 2013, Al-Alawi and Bradley, 2013, Bandivadekar, 2008, McManus and Senter, 2009), vehicle environmental advantages (Shepherd et al., 2012, Zhang et al., 2011, Caulfield et al., 2010) and vehicle variety (van den Bergh et al., 2006, Struben and Sterman, 2008).

Cost of ownerships factors including purchase price, vehicle payback period and operating cost, are stated as very influential in AFV adoption. When gasoline price increases, the adoption rate of HEVs will increase correspondingly (Caulfield et al., 2010, Brownstone et al., 2000). As the payback period shortens, people should be more willing to adopt AFVs (Al-Alawi and Bradley, 2013). Vehicle environmental advantages include factors like GHG emissions and fuel consumption. AFV vehicles that have less environmental impact will attract more consumers, especially for those that are more sensitive to environmental and sustainability issues (Oliver and Rosen, 2010, Lane and Potter, 2007, Ziegler, 2012). Vehicle variety includes the number and range of body types available in AFV models. More AFV models for consumers to choose from will increase the attractiveness of the technology because it will lead to more options for consumers to choose (Struben and Sterman, 2008).

These factors are often considered as vehicle attributes in AFV adoption models. Attributes with higher attractiveness like lower operating price, shorter payback period or lower GHG emissions can increase the adoption rate because consumers are more likely to choose AFVs that provide high utility. However, based on the observed adoption behaviour and historical trends in influencing factors, the relationships between the adoption rate and some vehicle attributes cannot be discerned.

2.2 Observed adoption behaviour in the Australia and the United States

In this study, we use the comparison of Australian and the United States AFV markets as an example to show the historical trend of the vehicle attributes and their impact to AFV adoption rate.

From historical data, we found that the number and body type variety of AFV models has a noticeable relationship with the AFV adoption rate (Figure 2 and Figure 3). The number and variety of Australian diesel vehicle models are significantly larger than that of Australian HEVs and US AFVs. The connection between the Australian diesel market share and number and variety of diesel models is rather strong as well (Figure 2). While for Australian HEVs and US AFVs, although the relationships between the number and variety of vehicle models are still noticeable, they are less evident (Figure 2 and Figure 3). The abundant and various diesel vehicle models in Australia suggest that the adoption of Australian diesel vehicles might has taken off while the HEV in Australia and AFVs the US have yet to see this coming.

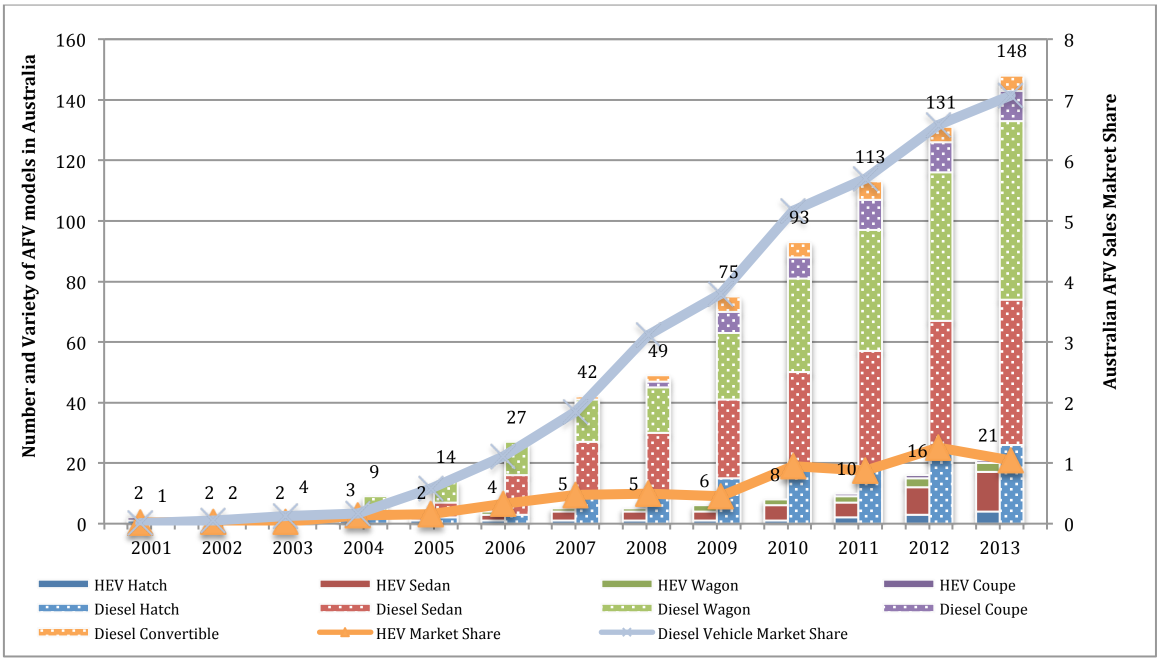

Figure 2 Number and body type variety of AFV models with AFV market share in Australia[2]

---

[2] Data source: Australian Federal Chamber of Automotive Industry and Redbook (Automated Data Services Pty Ltd)

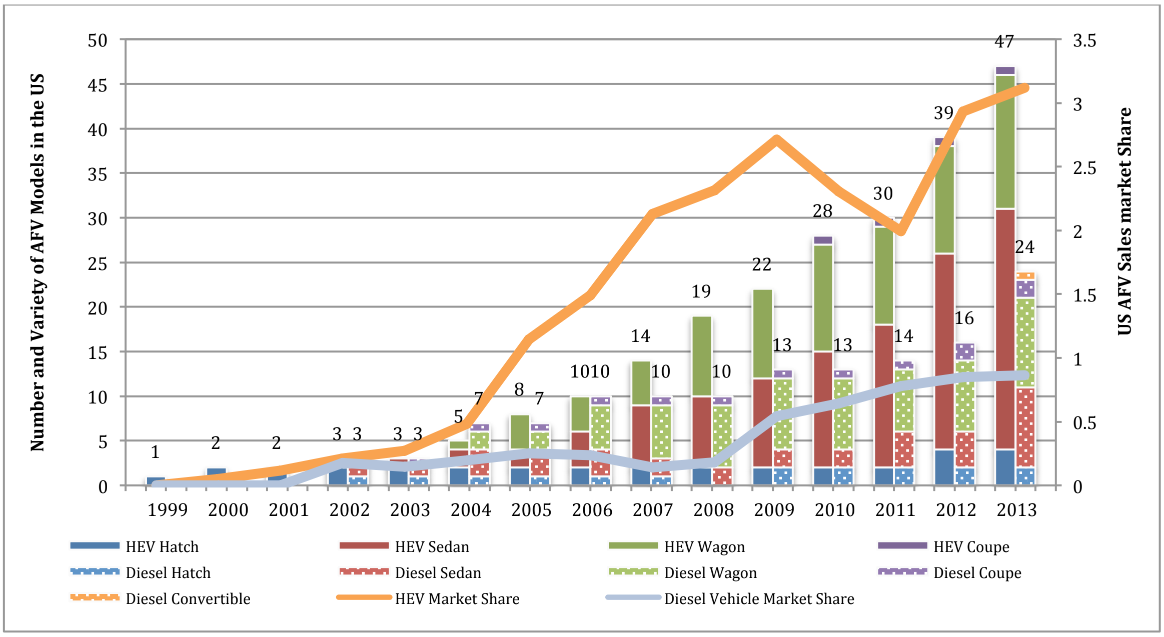

Figure 3 Number and body type variety of AFV models with AFV market share in the United States [3]

Influencing factors like GHG emissions and fuel consumption have improved during the years. Australian diesel vehicles, the most successfully adopted technology in relative terms, has drastically reduced its average fuel consumption, from 7.33L/100km in 2007 to 5.71L/100km in 2013 (GreenVehicleGuide, 2013). Fuel consumption for Australian diesel vehicles has dropped even below Australian HEV fuel consumption in 2013. With the technology becoming successful, the environment-related influencing factors also improve.

---

[3] Data source: Polk and Home.auto.msn.com

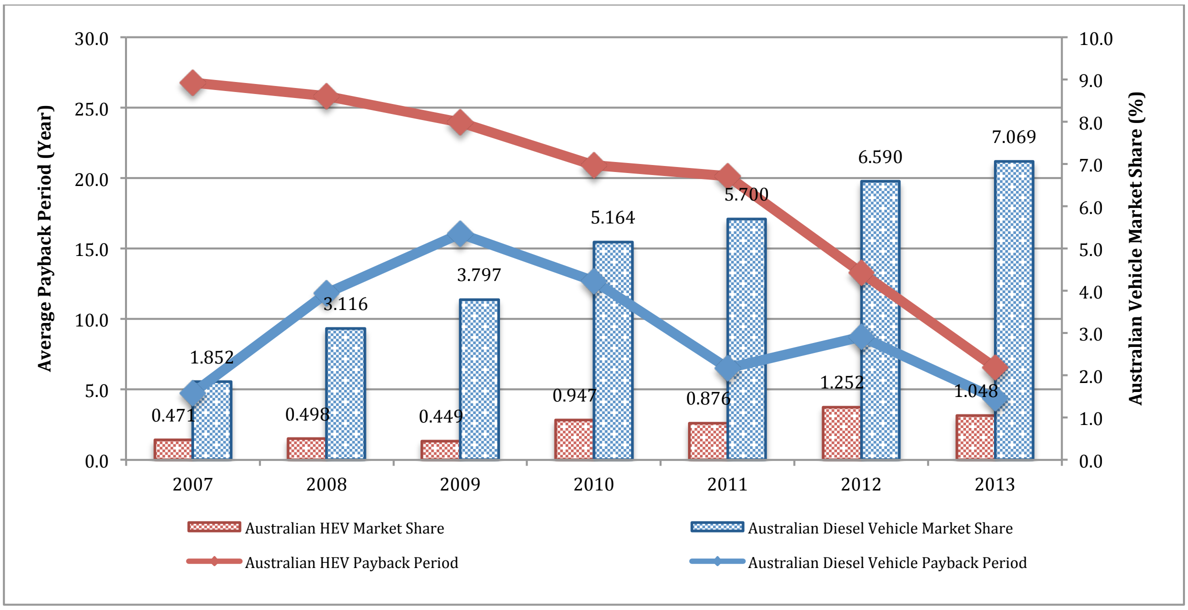

Figure 4 AFV payback periods and market share in Australia[4]

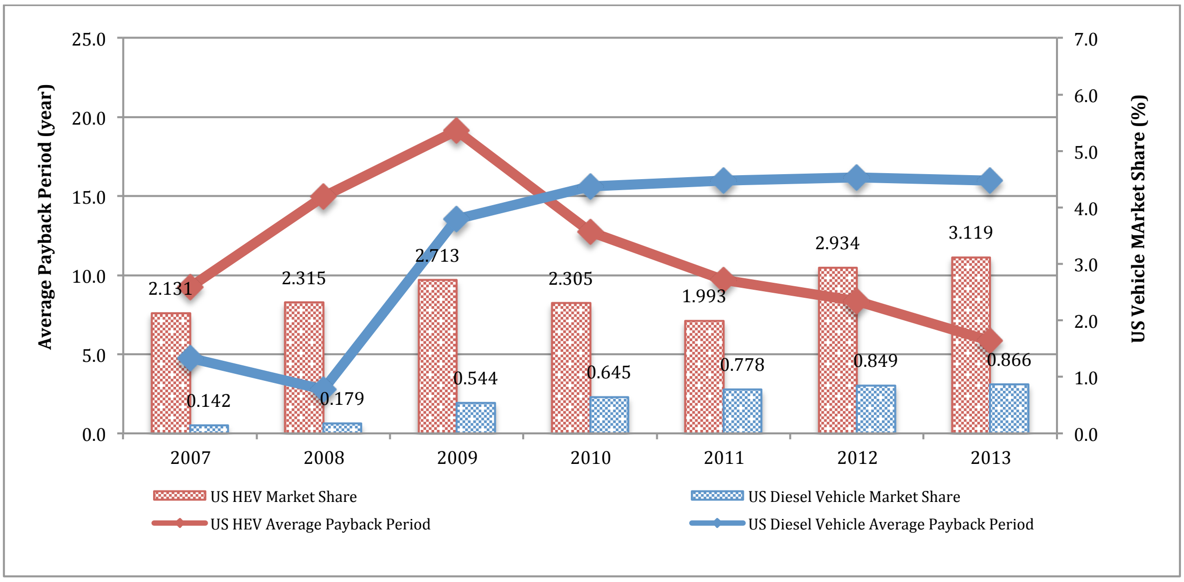

Figure 5 AFV payback periods and market share in the Unites States[5]

However, for other influencing factors, the connection is not that discernible. Shorter payback period and less operating cost are considered as beneficial to the adoption of AFVs (Al-Alawi and Bradley, 2013). Nevertheless, the impact of such vehicle attributes cannot be observed. In Figure 4 and Figure 5, the impact of payback periods for Australian and US AFVs on AFV adoption rate during 2007 to 2013 is unclear.

[4] Data source: Australian Institute of Petroleum and Green vehicle guide
[5] Data source: U.S. Energy Information Administration and Fueleconomy.com

2.3 Background summary

From the observed historical data, the influencing factors described above do not sufficiently reflect the disparate adoption behaviour of AFVs in Australia and the United States. Because previous studies focus on more localized areas, the models do not fully capture the differences between markets and also the competition between technologies when applied in a range of different markets.

In order to develop a hypothesis that captures variation in market conditions in different countries, a more generalized approach needs to be taken. Diffusion of technology describes the spreading of a technology into a social system while adoption of technology focuses more on individual decision-making and accepting the technology (Rogers and Shoemaker, 1971, Mahajan and Peterson, 1979, Tolba and Mourad, 2011). The individual adopting decision making process can be seen as the very fundamental aspect of technology diffusion (Zenobia and Weber, 2009). By looking at innovation diffusion at the individual level, the decision-making process by which an individual adopts or rejects a certain technology can be revealed; this provides valuable insights to the underlying dynamics of innovation diffusion in the social system.

In the individual adoption decision process, no matter if the consumer is from Australia or the United States, the basic decision-making steps should be the same. Factors like variances in market conditions, cultural differences and other social variables can be considered as adjustable inputs such that the hypothesis can be compatible for both markets.

In the following section, we look into consumer behaviour literature to understand the consumer decision-making process. After recognizing the individual adoption process, we incorporate it with system dynamic modelling so that the dynamic hypothesis can depict the disparate market adoption behaviour more accurately.

3 Consumer Decision-making Process

3.1 Consumer decision-making process theory

Decision-making theories have long been the interest of many researchers. A great number of subsequent theories have been developed to demonstrate the consumer's thought processes while purchasing something. One of the models that was developed in the 1968 and continuously perfected over time is the Consumer Decision Process theory by Blackwell et al. (2001). The model has been widely used in various consumer behaviour studies because it clearly presents the steps for need satisfying behaviour while comprises of a broad range of factors that influences decisions (Blackwell et al., 2001). It has six steps to depict the process of consumer decision-making: need recognition, information search, alternative evaluation, purchase, consumption and post-consumption behaviour (Figure 6).

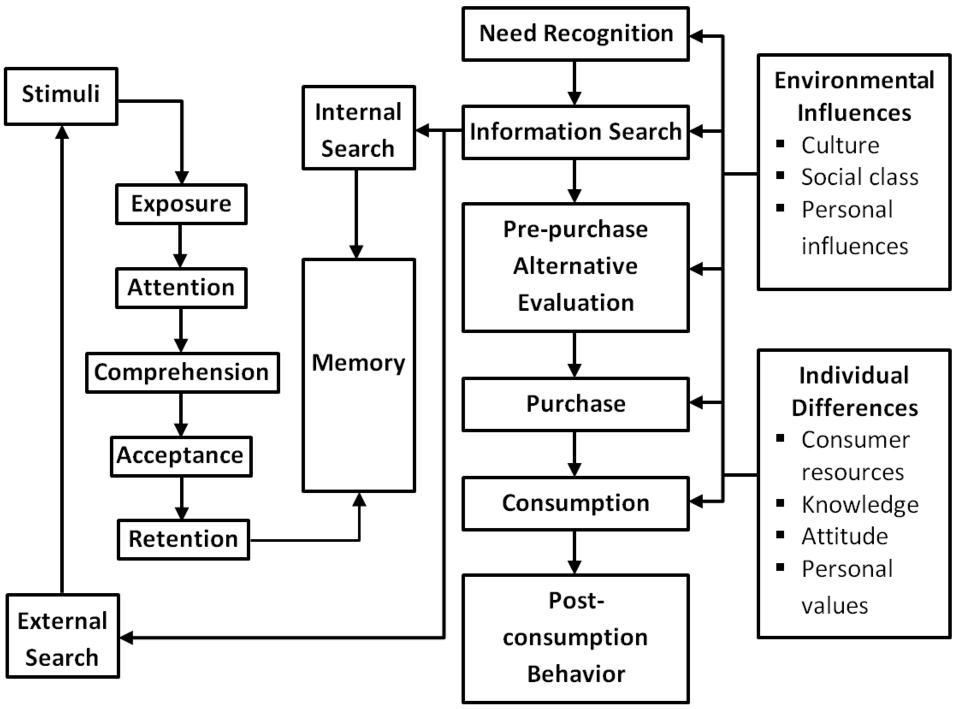

Figure 6 Consumer Decision Process model (Adapted from Blackwell et al. (2001))

The model provides a clear description of the process of consumer decision-making process. It starts with need recognition where consumer acknowledges a discrepancy between their ideal state and current state. In the scenario of vehicle purchase, this means consumer realizes the need for a new vehicle, with individual differences associated such as brand, body type and price range. The consumer then embarks on a search for information, internally from memory and externally from friends, websites and dealers, etc. The depth of the information search heavily depends on the environment. After acquiring enough information, the consumer progresses to the evaluation of the alternatives. Those alternatives are chosen from all available vehicle models and form a consideration set for evaluation (Hauser et al., 2014). The consumer evaluates the alternatives and commits to purchasing one model at "purchase" step. This process can be influenced by both environmental variables and individual variables (Figure 6).

3.2 Consumer adoption decision process theory

In the literature of diffusion of innovation, there are also theories and models that study individual decision-making behaviour during the diffusion process. This kind of consumer decision-making process is defined as *technology adoption decision process* (Zenobia and Weber, 2009). It depicts the dynamic sequence of actions and interactions occurred during the mental process of a consumer deciding to adopt or reject a technology (Zenobia and Weber, 2009).

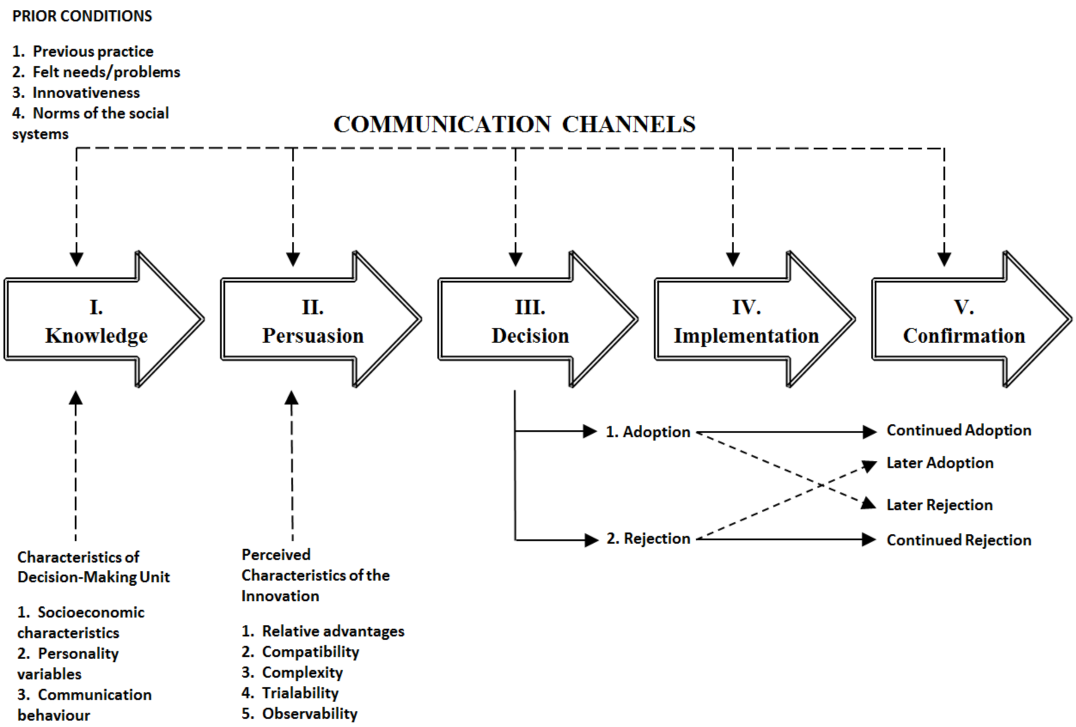

Figure 7 Adoption decision model with five stages (Adapted from Rogers (2003))

One of the most frequently cited models of the adoption decision process in diffusion of innovation literature was developed by Rogers (2003). In Figure 7, the five stages of adoption decision process in the model are presented: knowledge, persuasion, decision, implementation and confirmation. When compared to Consumer Decision Process model, this model puts more emphasis on the trail and consumption phase of the technology but lacks the step for information searching. Information searching, acts as a critical step in the Consumer Decision Process model, allowing the consumer to use both an internal and external search to gather information that they need to form the consideration set and perform the evaluation of alternative. In AFV purchase decision, information includes awareness of the AFV technology, opinions about AFV vehicles and eligible AFV models that fit the initial requirements of the consumer (discussed in Section 4 below). Because this information could have a critical impact on the final adoption decision and the overall system behaviour, we will add this step to the decision process of AFV adoption.

3.3 Applications using consumer adoption decision theories

There are several notable studies that look into the adoption decision-making process while trying to understand the technology diffusion of a certain product into the market. Labay and Kinnear (1981) based on adoption decision-making sequence (awareness--- attitude formation--- behavioural response), categorized the consumers of solar-energy technology into four groups: individuals who are unaware of the technology, individuals who are aware but have no interests, individuals who are interested in adopting and individuals who have adopted solar-energy technology. By investigating consumer preferences in those consumer groups, the study provided valuable insights about innovation attributes and their relationships with demographics in different consumer groups (Labay and Kinnear, 1981). In a more recent study, Brudermann et al. (2013) focused on investigating the factors included in the decision-making processes of farmers who adopted photovoltaic (PV) and who did not. The study identified the possible success factors and barriers in the adoption process of PV in the agricultural sector. Both these studies look into the underlying aspect of innovation diffusion and reveals insights about the process of consumer accepting a technology. However, because of these studies focus on the individual preferences and demographics, the overall dynamic of diffusion is overlooked. These studies do not depict the bigger picture about the changes in the social system when the adoption takes place.

By using system dynamic, this paper presents a dynamic hypothesis that is developed from the perspective of individual adoption behaviour and can also include the dynamics in the overall social system.

4 Dynamic Hypothesis

4.1 Decision making process in AFV adoption

From the Consumer Decision Process model (Blackwell et al., 2001) and adoption decision model (Rogers, 2003), we incorporate AFV adoption scenario to come up with the steps in AFV adoption decision process (Figure 8). In Figure 8, a vehicle consumer is in need of a new vehicle. The consumer starts to look for information about possible vehicle models from both internal source (memory) and external source (dealers, advertisements, online reviews of vehicles, etc.). It is only possible for the consumer to adopt the AFV if all of the following three conditions have been met: consumer is aware of the technology (Box B), consumer has positive opinions against the technology so that AFV models can be included in the consideration set for further evaluation (Box C) and also at least one AFV model exists in the market that fits the initial criteria of the consumer (Box A). Within the consideration set, the consumer will than evaluate all the alternatives and may become an adopter by committing to make an AFV purchase. After the vehicle life span, the consumer either decides to purchase an AFV again to remain as an adopter or decides to not to repurchase an AFV and therefore returns to being a vehicle consumer. After returning to the vehicle consumer pool, the consumer begins the whole process again and could end up being an AFV adopter or remaining a vehicle consumer for the next cycle.

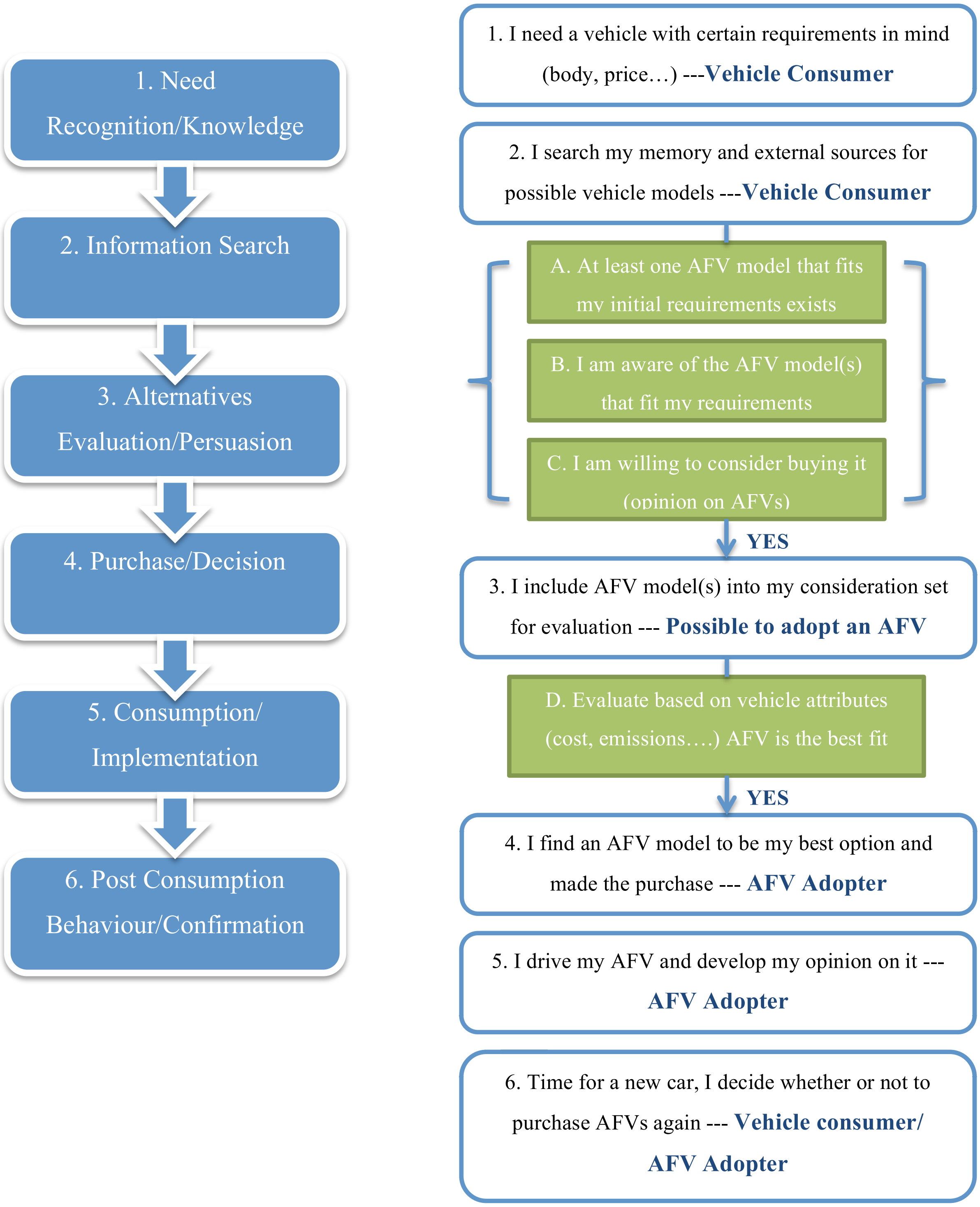

Figure 8 Consumer decision-making process on AFV adoption

4.2 Basic structure of the dynamic hypothesis

Based on the consumer decision-making process on AFV adoption (Figure 8), we develop the basic structure of the dynamic hypothesis. In Figure 9, the Bass diffusion model (Norton and Bass, 1987) is shown. In this model, the adoption is driven both by marketing and word of mouth effect (Bass, 1969). The balancing loop of market saturation makes sure that the adopters stock will reach its saturation level when every potential adopter has adopted the technology. The other balancing loop depicts the action where adopters return to the potential adopter pool by the end of the life span of the innovation.

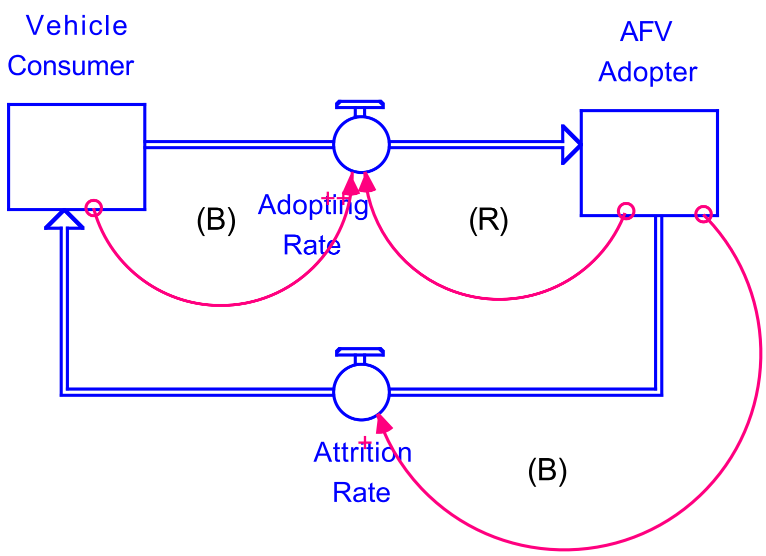

Figure 9 Bass diffusion model with repurchase (Adapted from (Sterman, 2000))

Influencing factors that impact the two rates in the adoption process are presented in Table 1 below. From previous studies, the main driver for the process is familiarity with the technology where more adopters in the market will create positive word of mouth among the social system and therefore boost up the number of adopters in return. In many studies, the Bass model has been expanded to include other familiarity factors that could drive the adoption as well, especially at the early stage where word of mouth effect hasn't taken off yet. Factors like marketing campaign and policy support (Eppstein et al., 2011, Diamond, 2009, Browne et al., 2012, Sullivan et al., 2009, Caulfield et al., 2010) will help the social system to accept the technology more smoothly and more quickly.

Vehicle attributes include cost of ownership, environmental advantages and model variety. As mentioned in section 2.1, these factors determine the attractiveness of the technology. If the time frame is long enough, vehicle attributes can also develop as adopter numbers increase and manufacturers invest more in the technology (Struben and Sterman, 2008).

Consumer demographics, mentioned as "individual differences" in Figure 6, can influence consumers' opinions about new technology (Centrone et al., 2007) and personal preferences towards different vehicle attributes (Eppstein et al., 2011, Cao and Mokhtarian, 2004). Therefore, it is one important variable to consider in adopting rate.

Table 1 Influencing factors in the Bass diffusion model

Rate	Influencing Factors
Adopting Rate	• Vehicle Attributes (cost of ownership, environmental advantages, number and body type variety of AFV models) • Familiarity (word of mouth, marketing campaign) • Consumer Demographics
Attrition Rate	• Average Vehicle Life

Based on the Bass model, we developed a dynamic hypothesis structure that also includes the process of consumer decision-making. From the adoption decision process in Figure 8, the step "Information Search" plays a significant role in the adoption process. During this step, there are three necessary conditions that have to be met (Figure 6). Firstly, the consumer has to be aware of the technology. Secondly, the consumer has to be familiar with the technology so that the AFV can enter consumer's consideration set. These two conditions are mainly affected by familiarity of the technology, which include word of mouth from AFV adopters and marketing campaigns. The third necessary condition is that there has to be at least one AFV model that fits the initial requirements of the consumer. This condition is affected by the number and body type variety of AFV models. Only if these three conditions are met, can the process move to the next stage.

For the third necessary condition, number and variety of AFV models, if there is no available model type that fits the consumer's basic requirements, the AFV cannot enter the consideration set even though the consumer is willing to try the new technology. For this reason, we propose that number and variety of AFV models is critical to people's willingness to consider AFV. This means the number and variety of AFV models can limit the consumers forming consideration sets that include AFV models and therefore act as a hurdle to the success of adoption.

There is also a significant dynamic behind variety of body types and number of AFV models: the number and variety of models will change over time as more consumers who are considering AFVs convert to become AFV adopters. Manufacturers look into the growth rate of AFV adopters to develop their strategies for whether or not to expand the line of AFV models. This growing rate of AFV adopters can be a much more sensitive and timely indicator of the market change than the number of adopters. By analysing the adopting rate, the manufacturers can make more timely decision in terms of growing the number and variety of the released AFV models.

For the above reasons, another stock between vehicle consumers and AFV adopters is proposed. We therefore introduce an extra stock, Possible Adopters, to allow the dynamic between model growth and the adopter conversion rate (Figure 10). Instead of becoming an AFV adopter directly from vehicle consumer (Figure 9), AFV consumer will go through three stages in the adoption process: becoming a possible adopter, then becoming an adopter and finally returning to vehicle consumers or remaining as an AFV adopter.

In Figure 10, the action "Willing to consider" means some percentage of general vehicle consumers are willing to include AFVs into their consideration set because there is at least one AFV model that fits their body type requirement and they are sufficiently familiar with the technology. The action "Adopting" represents the proportion of possible adopters who purchase an AFV based on evaluation of vehicle attributes. Both of the processes of vehicle consumers becoming possible adopters and possible adopters converting to adopters are based on the Bass diffusion model with repurchase model, but with different sets of influencing factors.

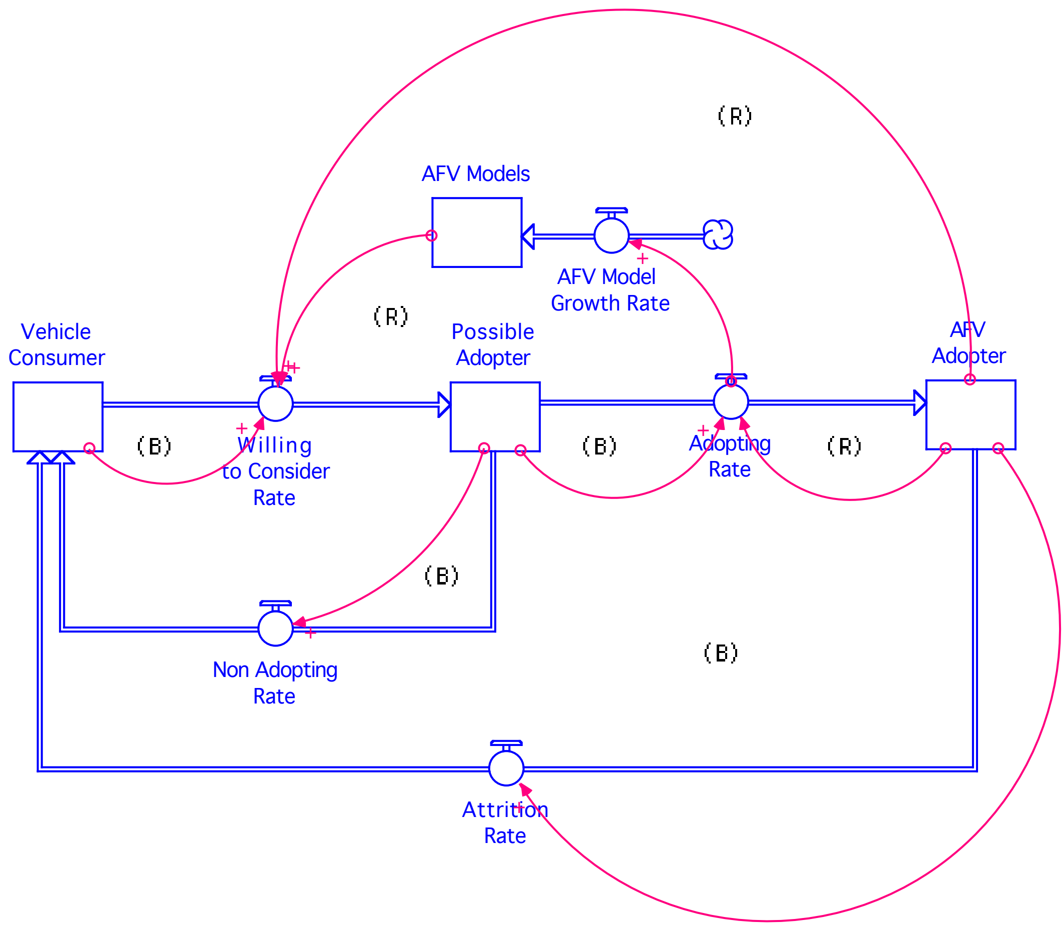

Figure 10 AFV adoption hypothesis basic structure

In Table 2, the influencing factors that can impact each rate at the three stages are presented. During the "willing to consider" action, there are two vital factors. One is familiarity with the technology, which is the same as Bass diffusion model and has been included in many AFV adoption studies before. The other is model variety, which is a necessary condition that must be met before the next step in the adoption process. Therefore, it has been separated from general vehicle attributes and added into this stage.

In the next stages, possible adopters evaluate their options within their consideration sets. In this stage, if the vehicle attributes of AFVs were more desirable to the consumer, the consumer will choose an AFV as their new vehicle. Otherwise, they fall back to the vehicle consumer group and begin the process after the life span of their ICE vehicles. In this step, consumers make rational decisions based on vehicle attributes and their personal preferences. When the AFV approaches the end of its life span, the consumer will consider replacing it with a new vehicle. Based on the former experience of driving an AFV, the consumer will choose either to purchase another AFV or return to the vehicle consumer pool to go through the process again.

Table 2 Influencing factors in the hypothesis

Rate	Influencing Factors	Relations with Consumer Behaviour
Willing to Consider	• Familiarity (word of mouth, marketing campaign, consumer demographics) • Model Variety (number and body type variety of AFV models)	These factors are influential during information search when consumers narrow their options into a consideration set.
Adopting	• Vehicle Attributes (cost of ownership and environmental advantages) • Consumer Demographics	These factors are influential while the consumer starts to evaluate the alternatives within their consideration set.
Non-adopting	• Vehicle Attributes (cost of ownership and environmental advantages) • Average Vehicle Life	The non-adopting rate is the opposite of the adopting rate where possible adopters decide to choose ICE vehicles after alternative evaluation.
Attrition	• Average Vehicle Life	Attrition rate will be mainly affected by product life span when the consumer chooses not to repurchase an AFV straight away.
AFV Model Growth	• Adopting rate	Adopting rate would be the most influential factor to model growth rate. Vehicle manufacturers evaluate the growth of certain technology (the adopting rate) to determine their strategies for model expanding.

The last rate in Table 2 is the rate of model growth. It is directly connected with adopting rate. As the adopting rate increase, vehicle manufacturers will consider the adopting rate when making the decision whether to expand the AFV line or not. Once the number and body type variety of AFV models increase to the same levels as ICE models, the impact of this variable on the “willing to adopt” rate will diminish.

4.3 System boundary and behaviour

System boundary in this hypothesis includes influencing factors such as word of mouth effect, vehicle attributes, number and body type variety of AFV models and vehicle manufacturers' capability, while government incentives, fuel price and marketing from vehicle manufacturers as exogenous factors (Table 3).

Table 3 System boundary of the hypothesis

Endogenous	Exogenous	Exclude
• Vehicle consumers/ Possible adopters /Adopters • Social exposure (customer familiarity) • Number and body type variety of AFV models • Vehicle attributes (purchase price, on-going cost, GHG emission) • Vehicle manufacturers' capability (R&D investment, experience gain)	• Government intervention (incentives, educational program and funding for vehicle manufacturers) • Fuel price • Vehicle manufacturers' efforts in marketing • Consumer demographics	• Vehicle depreciation • Vehicle second-hand market • Waiting-list for AFV • Inflation rate

The hypothesis will follow the S-shaped growth curve like in the Bass diffusion model. However, because the hypothesis has an extra stock, the adoption process will be slowed down. The extra hurdle caused by model number can also mean the possibility of adoption failure will be increased.

Considering the reinforcing loop caused by model growth and adopting rate, the adoption curve would grow faster to market saturation level than the Bass model once the technology has been successfully penetrated into the market (Figure 11).

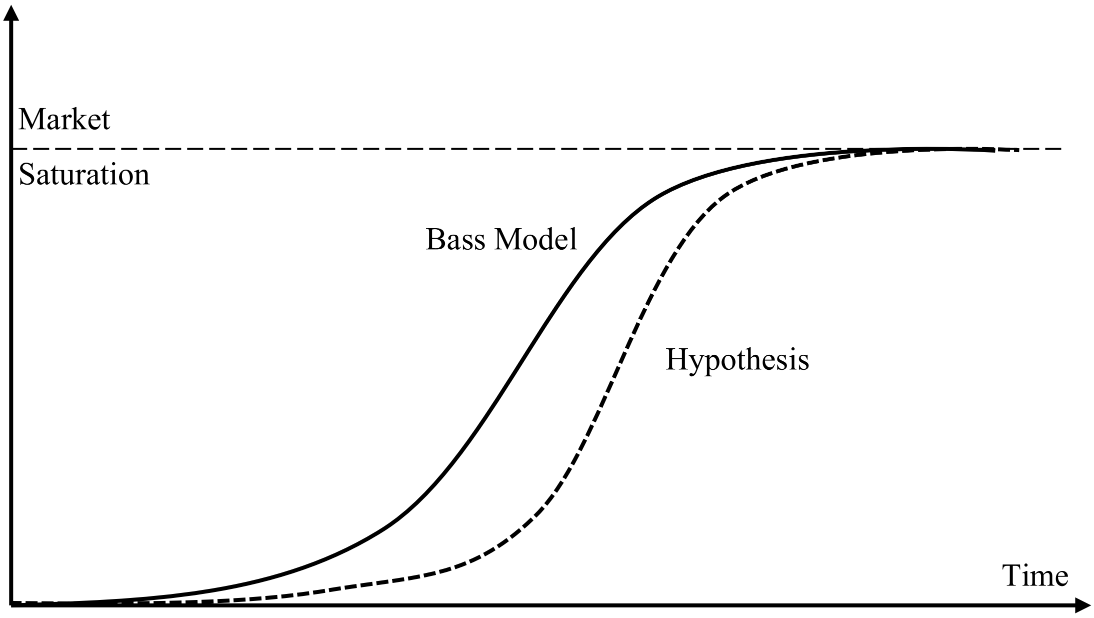

Figure 11 System behaviour of the hypothesis

5 Conclusion and Further work

This paper represents a dynamic hypothesis that incorporates the individual consumer adoption decision process into diffusion of innovation models. The hypothesis builds on the Bass diffusion model dividing the adoption process into three stocks where the vehicle consumers, the first stock, will become possible adopters, the second stock, by including AFVs into consideration set for evaluation and then adopters, the final stock, for deciding on purchase an AFV model.

The hypothesis is base on the fundamental Bass diffusion model and further advanced by individual consumer decision-making process theory. By incorporating both approaches, the hypothesis identifies the significant impact of number and variety of AFV models to the release of adoption success. The dynamics behind AFV model growth and adopting rate has been included into the Bass model in order to better describe the diffusion process.

The dynamic hypothesis introduced in this paper suggests a possible reason for understanding the diverse AFV adoption in the Australia and the United States. In order to further tackle the problem, the hypothesis needs to be tested by building a system dynamic model based on the Australian AFV market that incorporates consumer decision-making process.

Using real-world data to simulate the adoption behaviour can help quantify the relationships between influencing factors and the adoption rate. However, because the hypothesis depicts a national wide adoption scenario, data collection for consumer demographics, weekly-fluctuated fuel price, localized adoption rate in postal code areas and other variables could be overly complex and ineffective to verify the hypothesis.

One alternative way of measuring the influencing factors, especially those related to consumer decision-making process, is to use accompanying marketing survey to acquire relevant data about consumer familiarity and consumer preferences. In such way, the relationships between influencing factors and the adoption rate can be quantified without overly cluttered data.

Qualitative data can also be acquired by marketing survey where we could support the hypothesis by investigating the consumers' decision-making processes. In the study of Hauser et al. (2014), the authors used incentive-aligned preference measurement method to qualitatively depict the consumers' decision processes when purchasing a vehicle. This method provides consumers the opportunities to self-reflect prior to asking them to articulate their preferences. The study concludes that by doing the self-reflection, the consumer could better express their preferences more efficiently (Hauser et al., 2014). This method can be used to acquire the consumer adoption decision process and in turn provide qualitative support for the hypothesis.

6 References

AL-ALAWI, B. M. & BRADLEY, T. H. 2013. Total cost of ownership, payback, and consumer preference modeling of plug-in hybrid electric vehicles. *Applied Energy,* 103**,** 488-506.

BANDIVADEKAR, A. P. 2008. *Evaluating the impact of advanced vehicle and fuel technologies in U.S. light duty vehicle fleet.* Massachusetts Institute of Technology.

BASS, F. M. 1969. A new product growth model for consumer durables. *Management Science,* 15**,** 215-227.

BLACKWELL, R. D., MINIARD, P. W. & ENGEL, J. F. 2001. *Consumer Behaviour*, Harcourt College Publishers.

BROWNE, D., O'MAHONY, M. & CAULFIELD, B. 2012. How should barriers to alternative fuels and vehicles be classified and potential policies to promote innovative technologies be evaluated? *Journal of Cleaner Production,* 35**,** 140-151.

BROWNSTONE, D., BUNCH, D. S. & TRAIN, K. 2000. Joint mixed logit models of stated and revealed preferences for alternative-fuel vehicles. *Transportation Research Part B: Methodological,* 34**,** 315-338.

BRUDERMANN, T., REINSBERGER, K., ORTHOFER, A., KISLINGER, M. & POSCH, A. 2013. Photovoltaics in agriculture: A case study on decision making of farmers. *Energy Policy,* 61**,** 96-103.

CAO, X. & MOKHTARIAN, P. L. 2004. The Future Demand for Alternative Fuel Passenger Vehicles: A Diffusion of Innovation Approach. Davis, CA; University of California, .

CAULFIELD, B., FARRELL, S. & MCMAHON, B. 2010. Examining individuals preferences for hybrid electric and alternatively fuelled vehicles. *Transport Policy,* 17**,** 381-387.

CENTRONE, F., GOIA, A. & SALINELLI, E. 2007. Demographic processes in a model of innovation diffusion with dynamic market. *Technological Forecasting and Social Change,* 74**,** 247-266.

DIAMOND, D. 2009. The impact of government incentives for hybrid-electric vehicles: Evidence from US states. *Energy Policy,* 37**,** 972-983.

EPPSTEIN, M. J., GROVER, D. K., MARSHALL, J. S. & RIZZO, D. M. 2011. An agent-based model to study market penetration of plug-in hybrid electric vehicles. *Energy Policy,* 39**,** 3789-3802.

FEDERAL CHAMBER OF AUTOMOTIVE INDUSTRIES 2013. Key Facts About the Australian Auto Industry. Federal Chamber of Automotive Industries, .

GREENVEHICLEGUIDE. 2013. *Green Vehicle Guide* [Online]. Available: http://www.greenvehicleguide.gov.au/GVGPublicUI/Home.aspx [Accessed 10/10 2013].

HAUSER, J. R., DONG, S. & DING, M. 2014. Self-reflection and articulated consumer preferences. *Journal of Product Innovation Management,* 31**,** 17-32.

LABAY, D. G. & KINNEAR, T. C. 1981. Exploring the Consumer Decision Process in the Adoption of Solar Energy Systems. *Journal of Consumer Research,* 8**,** 271-278.

LANE, B. & POTTER, S. 2007. The adoption of cleaner vehicles in the UK: exploring the consumer attitude-action gap. *Journal of Cleaner Production,* 15**,** 1085-1092.

LEE, D. H., PARK, S. Y., HONG, J. C., CHOI, S. J. & KIM, J. W. 2013. Analysis of the energy and environmental effects of green car deployment by an integrating energy system model with a forecasting model. *Applied Energy,* 103**,** 306-316.

MAHAJAN, V. & PETERSON, R. A. 1979. First-purchase diffusion models of new-product acceptance. *Technological Forecasting and Social Change,* 15**,** 127-146.

MCMANUS, W. & SENTER, R. J. 2009. Market Models for Predicting PHEV Adoption and Diffusion. University of Michigan Transportation Research Institute.

NORTON, J. A. & BASS, F. M. 1987. A Diffusion Theory Model of Adoption and Substitution for Successive Generations of High-Technology Products. *Management Science,* 33**,** 1069-1086.

OLIVER, J. D. & ROSEN, D. E. 2010. Applying the Environmental Propensity Framework: A Segmented Approach to Hybrid Electric Vehicle Marketing Strategies. *Journal of Marketing Theory & Practice,* 18**,** 377.

ROGERS, E. M. 2003. *Diffusion of Innovations*, Free Press.

ROGERS, E. M. & SHOEMAKER, F. F. 1971. *Communication of innovations: a cross-cultural approach*, Free Press.

SELECTUSA. 2013. *The Automotive Industry in the United States* [Online]. SelectUSA: SelectUSA. Available: http://selectusa.commerce.gov/industry-snapshots/automotive-industry-united-states [Accessed 5th Jun 2014].

SHEPHERD, S., BONSALL, P. & HARRISON, G. 2012. Factors affecting future demand for electric vehicles: A model based study. *Transport Policy,* 20**,** 62-74.

STERMAN, J. D. 2000. *Business Dynamics: System Thinking and Modeling for a Complex World*, McGraw-Hill/Irwin.

STRUBEN, J. & STERMAN, J. D. 2008. Transition challenges for alternative fuel vehicle and transportation systems. *Environment and Planning B: Planning and Design,* 35**,** 1070-1097.

SULLIVAN, J., SALMEEN, I. T. & SIMON, C. P. 2009. PHEV market place penetration: an agent based simulation. University of Michigan Transportation Research Institute.

THE WORLD BANK 2011. Motor Vehicles (per 1,000 people). *World Development Indicators.* The World Bank, .

TOLBA, A. H. & MOURAD, M. 2011. Individual and cultural factors affecting diffusion of innovation. *Journal of International Business & Cultural Studies,* 5.

VAN DEN BERGH, J. C. J. M., FABER, A., IDENBURG, A. M. & OOSTERHUIS, F. H. 2006. Survival of the greenest: evolutionary economics and policies for energy innovation. *Environmental Sciences,* 3**,** 57-71.

ZENOBIA, B. A. & WEBER, C. M. Deciding to change: An event sequence analysis of consumer adoption behavior. Management of Engineering & Technology, 2009. PICMET 2009. Portland International Conference on, 2-6 Aug. 2009 2009. 2666-2676.

ZHANG, T., GENSLER, S. & GARCIA, R. 2011. A Study of the Diffusion of Alternative Fuel Vehicles: An Agent-Based Modeling Approach*. *Journal of Product Innovation Management,* 28**,** 152-168.

ZIEGLER, A. 2012. Individual characteristics and stated preferences for alternative energy sources and propulsion technologies in vehicles: A discrete choice analysis for Germany. *Transportation Research Part A: Policy and Practice,* 46**,** 1372-1385.