FACTORS INFLUENCING THE DIFFUSION OF BATTERY ELECTRIC VEHICLES IN URBAN AREAS

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Abstract

Purchasing a battery electric vehicle is a type of pro-environmental behavior but the impact of such behavior on the environment becomes significant and beneficial only if a large number of individuals buy it. Therefore, getting battery electric vehicles diffused in a social system is a critical task which needs a special attention from consumers as well as governments and suppliers. This thesis aims to find out all factors influencing the rate of adoption of a battery electric vehicle by using the main constructs and important concepts of theory of diffusion of innovations proposed by Rogers (1962). The results indicate that seven factors influence the rate of adoption of a battery electric vehicle including social pressure, social prestige, usefulness for environment, difficultly of use, price, perceived risk, and knowledge and information about battery electric vehicles. Based on these factors, a roadmap and a set of policies to accelerate the rate of adoption of battery electric vehicles were proposed.

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Dedications

I dedicate this thesis to my lovely wife, who has always stood by me and showed a great patience during my studies in Ryerson University.

I also dedicate this thesis to my late mother in law, an angle, who died just before my thesis defense meeting. She always loved me and supported me and my wife in every second of my studies in Canada.

Table of Contents

List of Tables

List of Figures

List of Appendices

Introduction

Innovations have surprisingly changed the way we are living today. If we look into twenty years ago and remember how we were living and compare it to our lifestyle today we become convinced that innovations more than everything else in this world make our life so different. Healthcare, banking, social communication, interpersonal relationships, learning, and a lot of other aspects of our life are influenced by the new products and services. Personal computers, internet, mobile phones, CT scans, on-line banking, Facebook and on-line learning are just some examples of new products or services that have changed our life forever.

Undoubtedly all new products and services are not successful in the market. In fact, we have seen or heard about some new products or services which were not diffused and adopted successfully in the market even though they were technologically advanced products. Therefore, this question comes to our mind that why some new products and services diffuse very rapidly in the market and some new products and services do not. There are cases of very useful innovations to the mankind which have come a very long way to become widespread, and this adds to the importance of this question. For example, it took decades that the use of seat belt in cars became widespread in US although nobody has doubt about the usefulness of seat belt for safety of car passengers in car accidents. (Rogers, 2003)

In the context of eco- friendly products- the products which are less harmful to environment- this question becomes critical (InTech, 2011). Most of the eco-friendly products suffer from common problems such as high price, low reliability, and lack of infrastructure. (Jansson and Marell, 2010; Montalvo, 2007) Therefore, finding which factors affect the diffusion of eco-friendly products is completely

important. This finding can help the manufacturers of these products to reduce the risk of failure of these products in the market. It can also help the change agents (individual, organization or government) who seek to secure the adoption of eco-friendly products or services offer more effective solutions.

In fact, for more than fifty years, both practitioners and researchers have tried to find out the various factors which influence the rate of adoption of different innovations. (Rogers, 1962; Fliegel and Kivlin, 1966; Ostlund, 1974; Tornatzky and Klein, 1982; Moore and Benbasat, 1991; Schmidt and Druehl, 2005; Jansson, 2010; Nakata and Weidner, 2011) In this research we would like to investigate the diffusion of battery electric vehicles in urban areas. Battery electric vehicle is a type of electric vehicle that runs purely on electrical power from battery packs. More specifically the objectives of this research are: (1) to investigate the barriers to widespread use of battery electric vehicles in urban areas, (2) to find the factors influencing the rate of adoption of battery electric vehicles and to discover the relative contribution of each factor to its rate of adoption, and (3) to provide some policies which speed up the adoption rate of battery electric vehicles in urban areas.

From different points of view this research is useful and interesting. From environmental point of view, the results of this research can provide some policies which can accelerate replacing internal combustion engine vehicles (ICEVs) with battery electric vehicles. This replacement can dramatically reduce exhaust gases which are one of the principal contributors to air pollution in urban areas. In addition, this replacement can also reduce the total wasted energy of urban passenger car fleets due to higher efficiency of battery electric vehicles. From the knowledge gap point of view, our research in diffusion of electric vehicles has a lot of contribution to both researchers and practitioners working in this field: First, as most of the research in diffusion of innovation was carried out on successful

innovations, our research on electric vehicles as an unsuccessful innovation can extend our knowledge about diffusion. (Rogers, 2003) In fact, through investigating the unsuccessful diffusion of electric vehicles in the past, we are able to uncover many factors which potentially can affect the diffusion of innovation in general. These factors may not be easily understood when researchers focus only on diffusion of successful innovations. (Rogers, 2003) Secondly, in contrast to many research on diffusion, which has conducted after adoption of innovation (retrospective research) (Rogers, 2003; Tornatzky and Klein, 1982), our research on diffusion of electric vehicles has a chance to be conducted before the probable complete diffusion of electric vehicles (predictive research). Therefore, we have a chance to gather data in a neutral way. This helps us to overcome the pro – innovation bias which exists in many research in the field of diffusion of innovations. (Rogers, 2003)

In this thesis, we first explain our research questions and then describe the main concepts of our theoretical framework which is theory of diffusion of innovation proposed by Rogers (1962) and review the literature in this field. In chapter 3, we explain our research model and our research hypotheses. Our research methodology is the subject of chapter 4. In chapter 5, we describe the steps we took for data collection and also discuss about the results derived from the data analysis. In chapter 6, we explain our proposed roadmap and a set of policies to accelerate the rate of adoption of BEVs in urban areas. Finally, in chapter 7, we highlight our research findings and contributions. In addition, some potential areas for further research in the field of diffusion of battery electric vehicles are suggested in the last chapter.

1
Research Problem and Question

1.1 Research Problem

It is more than one century that battery electric vehicles - a type of electric cars that run only on battery and have no auxiliary internal combustion engine – have been invented. Although the invention of battery electric vehicles was even before the invention of internal combustion engine vehicles, battery electric vehicles have never been diffused in the automotive market.

No one doubts that the electric cars specifically battery electric cars have a lot of advantages over internal combustion engines. The battery electric cars produce less and even no air pollution compared to internal combustion engine vehicles, the energy efficiency of electric cars are much higher than that of internal combustion engine vehicles, and electric cars specifically battery electric cars have a very smooth performance during acceleration and run without any noise due to lack of tailpipe. Figure 1-1 shows the total amount of CO2 emission produced by different types of vehicles. Part of the CO2 emission is produced in a power plant which provides fuel or electricity for a vehicle (Well to Tank) and the rest is produced by vehicle itself (Tank to Wheel). As it can be seen, the average amount of total CO2 emission produced by a typical battery electric vehicle (BEV) is about

half of the average amount of total CO2 emission produced by an internal combustion engine vehicle (ICEV).

As we explained, part of the total CO2 emission produced by a typical battery electric vehicle is as a result of the power plants operation which uses fusil fuels in order to generate electricity. These power plants in most countries are usually far from urban areas and do not directly cause air pollution in urban areas. In addition, if these power plants use renewable energies other than fusil fuels to generate electricity, the amount of CO2 emission produced by these power plants and consequently the total CO2 emissions produced by battery electric vehicles will reduce dramatically.

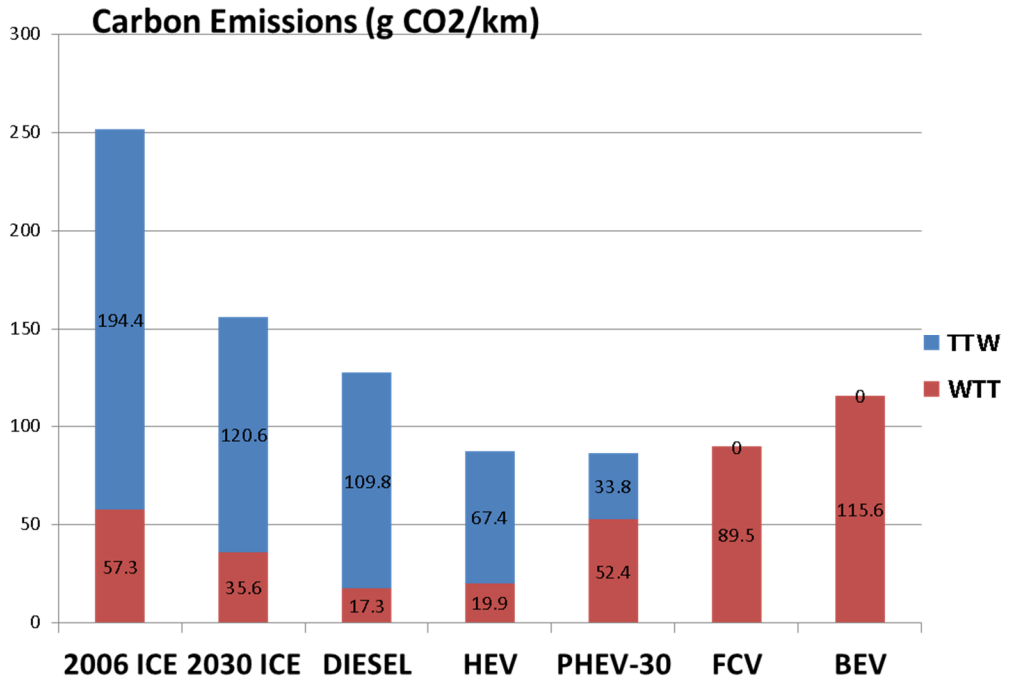

Figure 1-1 Well-to-Tank (WTT) and Tank-to-wheels (TTW) analysis of different vehicle types (Source: Kromer, M.A.; Heywood, J.B., 2007)

For example, in Ontario we have the great opportunity to reduce the total emissions produced by the transportation system by the widespread use of the battery electric vehicles. Table 1-1[1] shows the GHG[2] intensity per kWh electricity generated in Ontario Province. As it can be seen, the total CO2 emissions per kWh electricity generated in Ontario is about 100 g and therefore, given a typical battery electric car uses about 20 kWh per 100 km, the total CO2 emission produced by a typical battery electric in Ontario will be about 20 g per km which is less than 10 percent of total CO2 emissions produced by a typical ICEVs.

Ontario	Greenhouse Gas Intensity[1] (g GHG/kWh electricity generated)		
	1990	2008	2009[2]
CO_2 Intensity	190	170	100
CH_4 Intensity	0.002	0.01	0.01
N_2O Intensity	0.003	0.003	0.002
Overall Intensity[3] (g CO_2 eq/kWh)	190	170	100

Table 1-1 Ontario electricity and GHG intensity

Despite having all these advantages over internal combustion engine vehicles, the market share of battery electric vehicles is almost zero in the automotive market. Therefore, these questions have come to many researchers' mind that "what are the problems with these vehicles in the automotive market that they cannot be diffused in the automotive market despite having a lot of advantages over internal combustion engine vehicles? How can we overcome these

[1] Source: Environment Canada at http://www.ec.gc.ca/ges-ghg/default.asp?lang=En&n

[2] GHG: Greenhouse gas

problems and accelerate the diffusion of battery electric vehicles? Is it price problem that plays as a main barrier to widespread use of battery electric cars? Is it technology problem? Or it is an infrastructure problem? Many researchers and practitioners have tried to find the main reasons behind the unsuccessful diffusion of battery electric cars during the last fifty years and they have identifies the battery technology as the main factor that has impeded the diffusion of battery electric vehicles in the market. But recently, due to the advancement of technology of batteries, the role of other factors such as price, infrastructure, and consumer knowledge and information in diffusion of battery electric cars has also become important.

It seems that today more than ever some problems such as global warming, air pollution and energy crisis which are strongly connected to the widespread use of internal combustion engines in our transportation systems, put our life in danger. Therefore, the research on battery electric vehicles as one of the best solutions to these problems has gained momentum again and many researchers and practitioners have started looking to this research problem very seriously in order to find the main factors that influence the rate of adoption of battery electric vehicles and more importantly the relative importance of them (Jansson, 2010; Nakata and Weidner, 2011).

1.2 Research Question

Based on our research problem, in this research we are trying to find the answer for these research questions:

1- What factors influencing the adoption rate of battery electric vehicles in urban areas?

2- What is the relative importance of such factors?

In addition, we try to develop some policies which can speed up the adoption rate of battery electric vehicles in urban areas.

The nature of this question is predictive and we follow a deductive research strategy in our research. The research paradigm is positivism. In the positivism paradigm knowledge should be based on what can be objectively observed and measured, and assumes that observer objectivity is possible. (Williamson, 2002)

The theoretical framework for our research is the theory of diffusion of innovation proposed by Rogers (1962, 1983, and 2003) specifically we start from Rogers' framework in the rate of adoption of innovation. It should be notified that the diffusion of innovation field of study includes different research traditions such as anthropology, rural sociology, education, public health and medical sociology, communication, marketing and management, and etc. (Rogers, 2003). In this research we follow the literature on marketing and management tradition however according to Rogers (2003) by the mid-1960s, these research traditions began to merge into each other. Most of the marketing literature in diffusion focuses on the prediction of rate of adoption for new products and how the various factors such as perceived attributes of innovation can speed up the rate of adoption. (Rogers, 2003; Tornatzky and Klein, 1982) Research in the field of diffusion of innovation is a compelling area to investigate for the following reasons:

- Today, more than any time in human history, innovation plays a great role in social change. Paying a little attention to the past fifty years, we understand the unbelievable effects of innovation in our world. For example, the invention and diffusion of computers and internet has deeply changed our world. Therefore, the studies on different aspects of innovation such as diffusion of innovation will be quite interesting and exciting.

- One of the main challenges that most companies are facing today is how they can diffuse their new products into the market as quickly as possible. Research on diffusion of innovation can help them to find the most important variables affecting the speed of diffusion of a new product. Therefore, they can put most energy and time in a right direction.

To get better understanding of why this research question is persisting and relevant in the field of diffusion of innovation we briefly review the history of electric vehicles.

History of Electric vehicles

The first real and practical electric vehicle was invented by William Morrison in the late 1800s. (About.com, 2011) Very soon some companies in U.S.A., England and France began the development and manufacturing of electric vehicles. (About.com, 2011) In the beginning of 1900s the use of electric vehicles in some major cities of U.S.A. including New York, Boston, and Chicago became quite widespread so that the number of registered electric vehicles exceeded that of gasoline vehicles in these cities. (Sulzberger, 2004) the reasons behind the public interest to use electric vehicles instead of gasoline or steam-powered cars were quite apparent. The electric vehicles were running smoothly without any need to gear shifting. They didn't have any noise, smell or vibration compared to gasoline cars. In addition, they did not need any manual effort to start as it was needed for gasoline cars. Finally, at the time the only good roads in US were in urban areas with short commuting range that provided the ideal condition for electric vehicles which could not run in long ranges because of their limited energy capacity.

(About.com, 2011, D.J.Santini, 2011) The popularity of electric cars grew in U.S.A. up to 1920.

From 1920, the use of electric vehicles declined dramatically so that by the end of 1935 the electric vehicles completely disappeared in US market and were replaced by gasoline cars. Many factors accounted for technology shifting from electric motors to internal combustion engines at that time. First, the reduction in gasoline price due to discovery of Texas crude oil made gasoline cars more affordable. Second, the well development of inter-cities roads in US made high range driving between cities possible which caused using gasoline vehicles instead of electric vehicles. Finally the invention of electric starter in gasoline cars which eliminated the need for hand crank facilitated the use of gasoline cars. Of course the mass production of internal combustion engine cars at the same time helped the widespread use of these cars. (About.com, 2011) Regarding the price, while the price range of Ford model T was about $500 to $1000, the price of basic electric cars was about at least $1000. (About.com, 2011)

Energy crisis in the world in 1970s along with great worries about air pollution in large cities drew the attention of policy makers, non-governmental organizations and car makers to the benefits of electric vehicles as one of the best solutions to address such challenges. Trying to adopt to new emission regulations and also reduce the dependency to oil, some car makers launched some hybrid and pure electric vehicles in the market from 1970 to 2006. Honda's EV Plus, G.M.'s EV1, Ford's Ranger pickup EV, Nissan's Altra EV, Chevy's S-10 EV, and Toyota's RAV4 EV were all produced by big car makers in this time period. (PBS.org, 2009) Although the technology in various aspects of automotive industry including battery and electronic systems, body and driveline systems had increased dramatically but again electric vehicles could not compete with traditional vehicles. Therefore, all these cars were unsuccessful in the market and most of the

big US car manufacturers discontinued their electric vehicles production programs by the early 2000s. (PBS.org, 2009) The reasons behind this failure for electric vehicles were more or less the same as the reasons in 1920s.

A new wave of research and development on electric vehicles has initiated from 2010, resulting from growing concerns over global warming and oil supply reductions in the next ten years. In addition, the governments at all around the world including USA, Canada, most European countries, Australia, china and other countries have started placing electric vehicles as a part of their strategic vision for sustainable transportation system in the next decade. Undoubtedly for diffusing the new products such as electric vehicle the role of governments as the most important change agent is very critical. Generally the governments are able to speed up the adoption rate of electric vehicles in two ways: First, they can enforce new laws in reducing tailpipe emission which indirectly forces car manufacturers to produce eco-friendly products like battery electric cars. Second, the governments can give different incentives or subsidies to car manufacturers as well as to individuals in order to motivate them to produce and use electric vehicles.

Thanks to recent technological advances in battery systems and electronic control systems, the largest car manufacturers such as Ford, GM, and Toyota have new plans to launch new models of electric vehicles that can compete with gasoline vehicles at least in urban areas. For example GM plans to launch Chevrolet Volt model in the near future.

Undoubtedly, all above items make this research very compelling and we are confident that we are able to make a good contribution to both researchers and practitioners in diffusion of innovation field of study and car industry.

2
Theoretical Framework: Theory and Literature Review

There is increasing focus on environmental problems such as global warming, air pollution and high energy and material consumption are growing in recent years. People are showing more concerns about environment, companies and manufacturers try to produce more environmentally friendly products and governments are more determined to enforce laws and regulations which aim to protect the environment. (Stisser, 1994; Schwartz and Miller, 1991)

It is obvious that environment related behaviors performed by individuals, manufacturers and governments do not have the same impact. Stern (2000) defined environmentally significant behavior impact as "the extent to which it changes the availability of materials or energy from the environment or alters the structure and dynamics of ecosystems or the biosphere itself". In fact, in most cases the impact of local and world policies such as commodity prices on world markets, tax policies, and manufacturers' product and production strategies is greater than human behaviors that directly change the environment (Stern, 2000; Rosa& Dietz, 1998; Vayda, 1988). Therefore, any effort which aims to protect the environment

should consider the impact of all players including individuals, manufacturers and policy makers (governments).

Purchasing green products is one type of environmentally significant behavior (stern, 2000) but the impact of such behavior on environment is significant only if masses of individuals buy green products. Therefore, diffusion of green products in a social system is a critical factor to protect the environment. Clearly, in order for consumers to buy such products, manufacturers must supply green products at a reasonable price and quality and governments should support and promote buying such products. For example, buying an electric vehicle as a green product helps reduce air pollution only if a fair number of individuals in the same city buy this type of vehicle. For this, there should be various electric vehicle models in the markets and governments should provide the required infrastructure and promotions to motivate people to buy such products. From this point of view, diffusion of green products is a critical subject in environmental studies.

In broad context, making new products diffused in a society involves many factors and for more than fifty years, both practitioners and researchers have tried to find out the various factors that influence the diffusion of new products (Rogers, 1962; Fliegel and Kivlin, 1966; Ostlund, 1974; Tornatzky and Klein, 1982; Moore and Benbasat, 1991; Schmidt and Druehl, 2005; Jansson, 2010; Nakata and Weidner, 2011) Diffusion of innovation literature suggests that the perceived product attributes, communication channels, the extent of change agent promotion effort (government or individual organization), the nature of social system and types of innovation-decision (optional, collectively and authority) are the main factors which affect the diffusion of new products in a society.

The aim of this chapter is to review the diffusion of innovation theory proposed by Rogers (1962) in details and explain briefly the main concepts of this theory.

2.1 Diffusion of Innovation Theory

The theory of diffusion of innovation proposed by Rogers in 1962 tries to explain why one innovation diffuses or spreads successfully in a society and the other one does not. From the social point of view, diffusion of innovation is the spread of a new idea in the society and it is a type of social change. (Rogers, 2003) The speed of spread or diffusion of an innovation depends on many factors such as the perceived attributes of the new idea, the nature of social system, the communication channels within the society and etc.

The roots of diffusion theory are in sociology and anthropology and the research on diffusion of innovation dates back to the 1900s. Gabriel Tarde, a French lawyer and judge, was the first person who wrote about the diffusion of innovation (Rogers, 2003). In fact, Tarde was curious to know why only ten percent of different innovations have a chance to spread in the society and the other 90 percent fail to spread. He used the word imitation instead of innovation. Soon after Tarde, a group of scholars called the British diffusionist and the German-Austrian diffusionist came to believe that the social change in a society only results from the diffusion of innovation from the original source. Today we believe that the social change is a product of both invention which is the discovery or creation of a new idea and diffusion which is the spread of this new idea in a social system (Rogers, 2003). Anthropologists in the United States were the first scholars who were influenced by the works of European diffusionist and started investigating on diffusion of innovation (Rogers, 2003). The first scientific research in the diffusion field was conducted by Ryan and Gross (1943) who investigated the diffusion of seed corn in Iowa.

From 1940s, other scholars from different disciplines began working on diffusion of innovation and created different research traditions in this field

such as rural sociology, public health and medical sociology, communication, marketing and management. They used different methods of data gathering and analysis and different unit of analysis. For example while rural sociologist was using survey interviews and statistical analysis as their method of data gathering and analysis, the anthropologist was using participant and non – participant observation and case studies as their method of data gathering and analysis. (Rogers, 2003)

By the mid -1960s, most of the diffusion research traditions began to merge into each other and the research in diffusion of innovation became more cross – disciplinary. Today all research in diffusion of innovation categorized in eight different types (Rogers, 2003). Earliness of knowing about innovations, rate of adoption of different innovations, innovativeness, opinion leadership, diffusion networks, rate of adoption in different social systems, communication channel usage, and consequences of innovation. According to Rogers (2003), about 60% of research in the diffusion of innovation field is about the innovativeness of the members of a social system and they generally focuses on the effect of characteristics of members such as cosmopoliteness, communication channel behavior, resources, social status and etc. on innovativeness that means "the degree to which an individual or other unit of adoption is relatively earlier in adopting new ideas than the other members of a system" (Rogers, 2003).

In the next section, we explain the main elements of diffusion of innovation theory which helps us to have a better understanding of the factors influencing the rate of adoption of an innovation in a social system.

2.1.1 Main Element of Diffusion of Innovation Theory

Rogers (1983) has defined the diffusion of an innovation as "the process in which an innovation is communicated through certain channels over time among the members of a social system". According to this definition, four elements impact the diffusion of an innovation: innovation, communication channels, time and finally the social system.

There are a lot of different definitions for innovation, but at the broad level an innovation is a product, process or idea which is perceived as new by a society, organization or individual. Perceived attributes of an innovation have significant impact on the rate of diffusion. According to Rogers (1983) these attributes are: (1) relative advantage, (2) compatibility, (3) complexity, (4) trialability, and (5) observability. Relative advantage is "the degree to which an innovation is perceived as being better than the idea it supersedes" (Rogers, 2003) the degree of relative advantage can be expressed as financial advantage, social prestige and etc. Compatibility is "the degree to which an innovation is perceived as consistent with the existing values, past experience, and needs of potential adopters" (Rogers, 2003). An innovation that is not compatible with the personal values of an adopter or with norms of a social system or even with the habits and past behavior of an individual will not be adopted as rapidly as an innovation that is compatible. Complexity is "the degree to which an innovation is perceived as relatively difficult to understand and use" (Rogers, 2003). Trialability is "the degree to which an innovation may be experimented with on a limited basis" (Rogers, 2003). Observability is "the degree to which the results of an innovation are visible to others" (Rogers, 2003).

The logic behind defining and using these attributes by Rogers in diffusion theory is very clear. From Rogers' point of view, diffusion of innovation is a

special type of communication in which the messages are about a new idea (Rogers, 2003). Therefore, when an individual receives this message, if he perceives that this message has several relative advantages for him, is compatible with his norms and habits, is easy for him to understand and use, is observable, and finally it is trialable, it would be more probable that this individual adopts this message.

The other important element in diffusion of innovation is communication channels. As we explained earlier in this article, diffusion of innovation is a special type of communication in which two individuals or units of adoption, one who has knowledge of, or has used, the innovation and the other one who does not have knowledge of, or has not yet used, the innovation exchange the specific message which contains a new idea through a communication channel. According to Rogers (2003) there are two different communication channels: mass media and interpersonal channels. Each of these communication channels has two functions: awareness-knowledge function and persuasion function. While mass media such as television, newspapers, radio and so on have been applied more on transmission of awareness-knowledge or simply information, interpersonal relationship channel is more effective on persuasion and motivation. For example, mass media channels are more effective when a company wants to convey some general information about its new product to people but when it comes to make a final decision to adopt or reject an innovation, definitely interpersonal channels play the main role. (Rogers, 2003) In the last decade, the Internet as an interactive communication means plays an important role in providing information and even persuading people to adopt a new idea.

Time is a third element in the diffusion of innovation. Time is important in the diffusion process because it is served as a dimension by which we are able to analyze the speed of diffusion. For example, as a change agent in a society, we are

curious to know the rate of adoption which is the number of people in a society who adopts the innovation in a given time period. In addition, time is involved in the analysis of the innovativeness which is "the degree to which an individual or other unit of adoption is relatively earlier in adopting new ideas than the other members of a system" (Rogers, 2003). Moreover, time is an important factor in innovation-decision process. The innovation-decision process is the process through which an individual makes a decision to adopt or reject an innovation. It usually starts when an individual or other unit of adoption receives information about an innovation and becomes aware of it and it ends when he makes a final decision to adopt or reject the innovation. The innovation-decision process includes five main steps: (1) Knowledge, (2) persuasion, (3) decision, (4) implementation, and (5) confirmation.

The first step in the diffusion process starts when an individual or other unit of adoption gains the information about the existence of an innovation and how it functions. Based on this knowledge and information, an individual forms a favorable or unfavorable attitude toward the innovation and persuaded or not persuaded to adopt the innovation. The attributes of the innovation and how an individual perceives those attributes play important roles in this step. In the next step, an individual makes a decision to adopt or reject the innovation. If an individual adopts an innovation, he implements his decision by buying and putting the innovation into use. The last step is confirmation in which an individual continues to use the innovation.

Members of a society are not the same in terms of when they adopt an innovation. Some members adopt an innovation earlier than others. Rogers (2003) divides people based on innovativeness into five groups: (1) innovators, (2) early adopters, (3) early majority, (4) late majority, and (5) laggards. There is a vast amount of research on innovativeness and the effect of characteristics of members

of a society on innovativeness. For example, according to Rogers (2003) research shows that innovators are very active information seekers about new ideas, they have a wide interpersonal network, more access to mass media, and they can deal with high levels of uncertainty.

The social system is the fourth element in diffusion of an innovation. Social system can affect diffusion process in several ways. Social structure, social norms, opinion leaders, change agents, types of innovation-decisions, and consequence of an innovation in a society are the main concepts in this area which can influence the diffusion of an innovation. Diffusion takes place within the social system so the boundary of a social system limits diffusion of an innovation. Each social system has a structure. According to Rogers (2003) structure is "the patterned arrangements of the units (individuals, organizations, informal groups, and etc.) in a system. Social structure gives stability and regularity to human behavior so from this point of view, understanding the structure of a social system helps us to predict behaviors of the members of that society. There are two types of structure: formal structure and informal or communication structure. While formal structure of a social system gives us broad information about the position and behavior of each units of that system, the communication structure of a social system reveals who interacts with whom and under what circumstances. The communication structure of a social system is of special interest of social psychologist because it explains some variation of an individual behavior within a social system.

Social norms are another factor that affects the diffusion of an innovation. Rogers (2003) defines norms as the established behavior patterns among the members of a social system. The function of the norms in a society is to guide and standardize the behaviors of members of a social system. If an innovation is not

compatible with norms of a society, its chance to be diffused within that society decreases considerably.

Opinion leaders in a social system are those who can influence the other individuals' attitude or behavior in a desired way. Opinion leaders are usually at the center of interpersonal communication networks and so their effect on the behaviors of other members of network is considerable. The behaviors of opinion leaders usually reflect the norms of a social system in which they exert their influence and their followers see them as a model for innovation behavior (Rogers, 2003).

A change agent is an individual who influences other individuals in a direction which is desirable by change agency. Change agency is often an organization or a government that supports or sponsors an innovation and tries to facilitate the diffusion of innovation in a society. In some cases the mission of a change agent is to slow down diffusion and prevent the adoption of undesirable innovations (Rogers, 2003) Governments as change agencies have a critical role to speed up or slow down the diffusion of innovations. Governments can affect the diffusion of innovations in several ways such as enforcing the laws and regulations to mandate the adoption or prevent the adoption of an innovation, offering subsidizes and incentives or investing in infrastructure to facilitate the adoption of an innovation. In the context of green products, governments play a critical role to motivate people to adopt such products through implementing incentive programs and to make use of green products easy by developing the required infrastructure.

A social system can influence the adoption of an innovation through forcing the members of a social system to adopt or reject an innovation. From this point of view, there are three types of innovation-decisions: optional innovation-decisions, collective innovation-decisions, and authority innovation-decisions. While in optional innovation-decisions, the decision to adopt or reject an innovation made

by an individual is completely independent of the decisions of the other members of the systems, in authority innovation-decisions, the decision to adopt or reject an innovation made by an individual is completely dependent to decisions made by people in authority in organizations, governments or communities. The collective innovation-decision is a type of innovation-decision made by consensus among all members of the social system (Rogers, 2003).

The consequence of an innovation is another factor which affects the adoption of an innovation. Consequences of an innovation can be different for individuals and social system. If an individual cannot perceive the benefits of adopting an innovation in a short-term, or an innovation has more desirable consequences for society than each individual, such innovations diffuse very slowly in a social system. The best examples of such innovations are green or eco-friendly products which have more desirable consequences for society than each individual and usually individuals cannot perceive the short-term benefits by adopting such products.

As we see, there are a lot of factors which affect the diffusion of an innovation in a social system. According to Rogers (2003) five main variables which can explain the rate of adoption of innovation are: (1) the perceived attributes of innovations, (2) Types of innovation-decision (Optional, collective, and authority), (3) Communication channels, (4) Nature of the social system and (5) Extent of change agents' promotion efforts. Rogers (2003) defined the rate of adoption as "the relative speed with which an innovation is adopted by members of a social system" Figure-1 shows these five independent variables which affect the rate of adoption. According to Rogers (2003) little diffusion research has been carried out to determine the relative contribution of each of these five types of variables on innovation's rate of adoption.

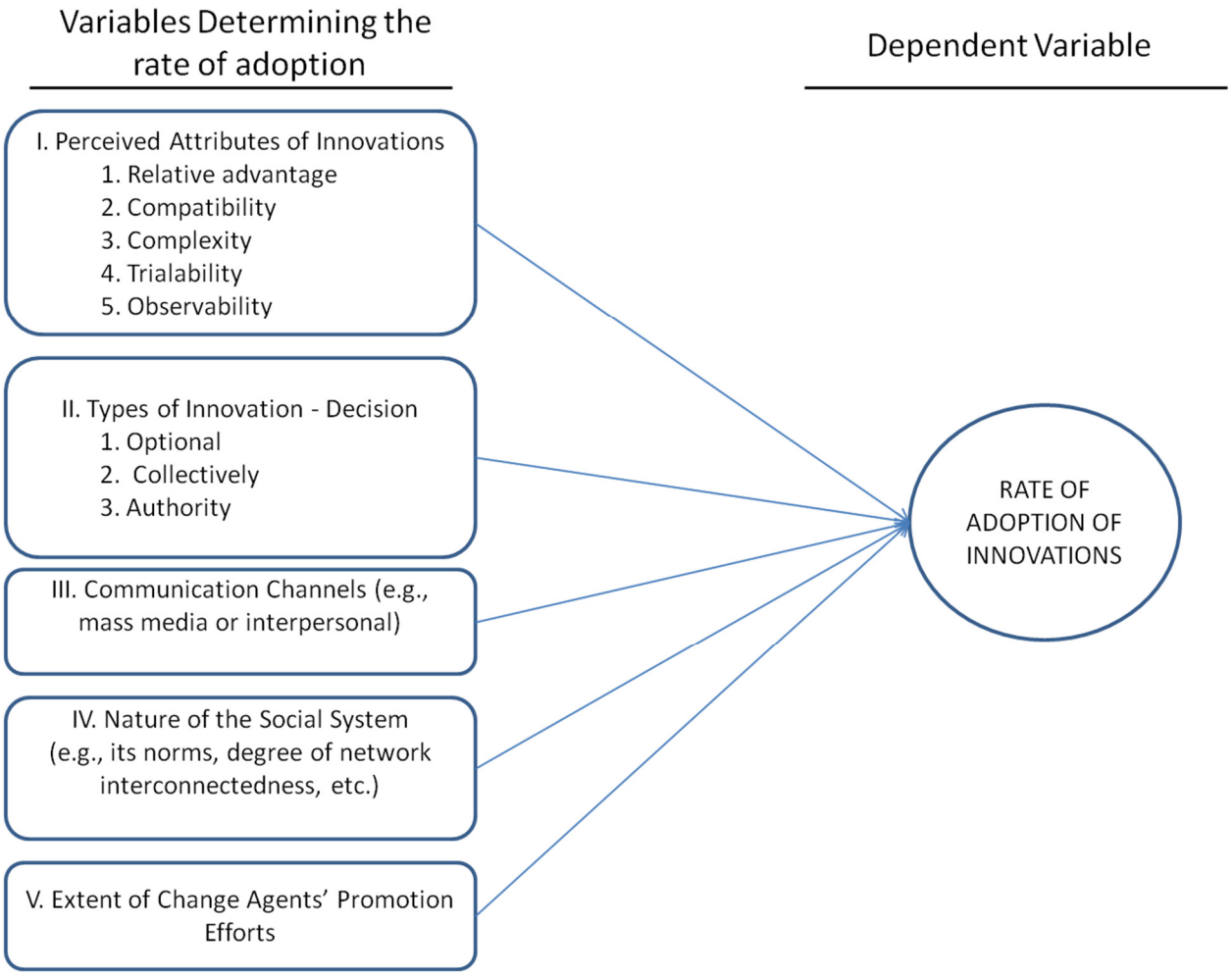

Figure 2-1 Variables Determining the Rate of Adoption of Innovations (Source: Rogers, 2003)

The perceived attributes of innovations including the five variables: relative advantage, compatibility, complexity, trialability and observability are the most important variables which according to Rogers (2003) most of the variance in the rate of adoption of innovation, from 49 to 87 percent, can be explained by these five variables. Most of the studies within DOI framework in the past fifty years have tried either to test the validity of these five constructs or to use them in their research in order to explain or predict new products' rate of adoption. (Fliegel and

Kivlin, 1966; Ostlund, 1974; Tornatzky and Klein, 1982; Moore and Benbasat, 1991; Schmidt and Druehl, 2005; Jansson, 2010; Nakata and Weidner, 2011) Bauer (1960) added perceived risk to these five constructs. He found that the perceived risk relates negatively with new product purchase or innovation behavior. (Ostlund, 1974; Labay and Kinnear, 1981)

One of the problems with the variables defined by Rogers in his theory is that these factors are very general and some of them overlap with each other (Lane and Potter, 2007). For example, the relative advantage variable can include a wide range of factors such as financial or economic factor, social status or prestige factor, and technical factors. Another example is interpersonal channels factor in communication channels category which conceptually seems to overlap with informal communication structure in social system category. It seems that both interpersonal channels and informal communication structure influence an individual's adoption-decision process in the same way by persuading him or her to adopt an innovation.

Lack of paying enough attention to values and attitudes is another problem with Rogers DOI theory. Although Rogers explains the persuasion phase in innovation-decision process in which an individual forms favorable or unfavorable attitudes toward an innovation, he does not clearly refer to attitudinal factors which affect an individual decision to adopt or reject an innovation. A huge number of empirical studies in environmental psychology investigate the role of attitudinal factors in consumer behavior (Jansson, 2010).

Market competition and availability of various products in terms of different prices and features in a market are other factors which Rogers has not taken into account in his diffusion of innovation theory. Market competition usually positively affects the price and quality of innovations in market which in turn motivate more people to adopt an innovation. Availability of various products in

different segments of market and with various features also affects the diffusion of an innovation.

2.1.2 Factors influencing the rate of adoption: A literature review

The literature on diffusion of innovation is very extensive and includes different domains. In fact, the roots of diffusion theory are in sociology and anthropology and the research on diffusion of innovation backs to 1900s. Anthropologists in United States were the first scholars who started investigating on diffusion of innovation (Rogers, 2003). The first scientific research in diffusion field was conducted by Ryan and Gross (1943) who investigated the diffusion of seed corn in Iowa. From 1940s, the other scholars from different disciplines began working on diffusion of innovation and they created the different research traditions in this field such as rural sociology, public health and medical sociology, communication, marketing and management and etc. (Rogers, 2003). By the mid - 1960s, most of the diffusion research traditions began to merge into each other and the research in diffusion of innovation became more cross – disciplinary. Today actually all research in diffusion of innovation categorized in eight different types: Earliness of knowing about innovations, rate of adoption of different innovations, innovativeness, opinion leadership, diffusion networks, rate of adoption in different social systems, communication channel usage, and consequences of innovation (Rogers, 2003).

Research on the rate of different innovations deals with various factors (independent variables) influencing the rate of adoption of an innovation (a dependent variable). The unit of analysis in this type of research is innovations. There are a lot of factors which affect the rate of adoption of an innovation in a social system. According to Rogers (2003) five main variables which can explain

the rate of adoption of innovation are: (1) the perceived attributes of innovations, (2) Types of innovation-decision (Optional, collective, and authority), (3) Communication channels, (4) Nature of the social system and (5) Extent of change agents' promotion efforts. Rogers (2003) defined the rate of adoption as "the relative speed with which an innovation is adopted by members of a social system".

The perceived attributes of innovations including the five variables: relative advantage, compatibility, complexity, trialability and observability are the most important variables which according to Rogers (2003) explain most of the variance in the rate of adoption of innovation, from 49 to 87 percent. One of the best representatives of this type of the research is the research conducted by Fliegel and Kivlin in 1966. Based on data on thirty-three modern farm practices (innovations), they investigated the effect of fifteen attributes of those practices on their rate of adoption. They divided all fifteen attributes into six main categories: (1) cost attributes, (2) returns, (3) efficiency (4) risk and uncertainty, (5) communicability of the innovation and its effects, and (6) congruence. Cost attributes, returns, and efficiency in their studies represent relative advantage, risk and uncertainty is very close to trialability, communicability of the innovation and its effects is very close to both complexity and observability, and congruence is very close to compatibility. The results of their study indicate that while more expected returns, less risk, and more efficiency positively affect the rate of adoption, the initial cost, complexity (communicability of the innovation and its effect), and compatibility (congruence) do not have any effect on the rate of adoption. The most important point in Fliegel and Kivlin research is that they used more than thirty-three innovations in their studies and analyze the correlation between perceived attributes of innovations with the rate of adoption of those innovations. As we will explain later in this article, one of the weaknesses of this type of research in

diffusion studies (research on rate of adoption as dependent variable versus perceived attributes of an innovation as independent variables) is that most researchers have only used one innovation or a limited number of innovations in their studies so their studies are not sufficiently robust and they cannot generalize their findings to a population of innovations. (Tornatzky and Klein, 1989; Rogers, 2003)

While according to Ostlund (1974) most studies in diffusion of innovation had focused on innovativeness of members of a social system to find out the relationship between innovativeness and personal characteristics of members in agricultural context, his research tried to uncover the relative importance of perceived attributes of two new consumer products and personal characteristics on innovativeness (the decision to buy or not to buy). His findings indicate that (1) personal characteristics such as age, education, family income, self-confidence, and etc. has no effect on innovativeness and (2) while relative advantage, compatibility, and observability were the most important predictors of purchase of the first product, relative advantage, perceived risk, and complexity were the most important predictors of purchase of the second product. These two studies revealed that (1) perceived risk as Bauer (1960) conceptualized is an important factor which can explain some variance of adoption of an innovation and should be added in diffusion studies, (2) perceived relative advantage has a broad meaning and can include a variety of variables so researchers preferred not to use directly this variable and replaced it with more sensible and understandable variables such as cost, pay off, efficiency, saving and etc., and (3) researchers ignored the effect of other factors such as social norms, change agent effort (in the second study the marketing effort for selling the consumer product), and communication channels on the rate of adoption and only tested part of Rogers' diffusion theory.

In order to find those characteristics of innovations which have the most consistent relationships to innovation adoption and implementation, Tornatzky and Klein (1982) conducted a review and meta-analysis of seventy five articles concerned with diffusion of innovations. From two points of view, the research performed by Tornatzky and Klein are important: first, they characterized the ideal innovation attribute research by proposing some features that each diffusion study should include. According to Tornatzky and Klein (1982), diffusion research studies should predict, rather than simply explain what happened to an innovation in terms of adoption or rejection. In other words, diffusion researchers should be employed more longitudinal approach in their studies than a one-shot cross-sectional methodology. In addition, diffusion research studies should focus on both adoption and implementation as the dependent variables, and not just adoption decisions. In addition, researchers should use more than one innovation in their studies in order to be able to generalize their findings because the unit of analysis in this type of the research is innovation and researchers should show statistically there is a correlations between the rate of adoption of the sufficient numbers of innovations with perceived attributed of innovations otherwise from statistical point of view the results are not generalizable. Second, they found three innovation characteristics including compatibility, relative advantage, and complexity had the most consistent significant relationships to rate of adoption of different innovations in different contexts. However, they strongly rejected the notion that relative advantage can be a good measure in diffusion studies. According to Tornatzky and Klein "if relative advantage is measured in terms of profitability, or social benefits, or time saved, or hazards removed, why bother to refer to relative advantage at all?" The other contribution of Tornatzky and Klein work was to reject the Downs and Mohr's (1976) notion that constructing a typology of innovations based on perceived characteristics in order to generalize

across different organizations or sites is not possible because “an innovation might be seen as minor or routine by some organizations but as major or radical by others” (Downs and Mohr, 1976).

In the context of information system and technology, research on diffusion of innovation was at first focused on the acceptance and use of a new technology only based on its perceived characteristics. In other words, for any reason researchers ignored the effect of other factors such as peers, managers, organization norms and etc. on acceptance of a new IS technology. For example, Davis (1989) proposed the technology acceptance model (TAM) based on two perceptual variables: perceived usefulness and perceived ease of use. Later, IS researchers considered the effect of other factors such as those mentioned above as well as perceptual variables on technology acceptance by applying behavioral theories. It is important to note that researchers in IS field have used the three words: diffusion, adoption, and acceptance in their articles. According to Williams et al (2009), “Adoption” was used by 59.1% of the papers published from 1985 to 2007 in 19 peer-reviewed journals, followed by ”Acceptance” by 26.9% and the term “Diffusion” was used by only 14%. While both adoption and acceptance in this context mean to start the use of technology and apply to individual decision level, diffusion means the spread of technology among members of a social system. Williams et al (2009) research results indicate that most of the research in the IS field have tried to find out the most important determinants of adoption or acceptance of a technology at the individual level. In other words, IS scholars are curious to know what causes people to accept or reject an information technology. (Davis, 1989)

TAM proposed by Davis (1989) is one of the most influential theories in IS field. TAM theoretical framework is grounded in cost-benefit theory, diffusion innovation theory and self-efficacy theory. Davis (1989) defined perceived

usefulness and perceived ease of use as two fundamental determinants of user acceptance. According to Venkatesh (1999), empirical studies found that TAM consistently explains around 40% of variance in usage intentions and behavior. One of the weaknesses of TAM is that it ignores the effect of organizational context on usage acceptance (Taylor and Todd, 1995). In addition, it overlooked the determinants of perceived usefulness as the most important determinant of usage acceptance (Venkatesh and Davis, 2000)

In parallel to attempts made by scholars in IS field to develop a comprehensive model for adoption and diffusion of information technologies, Moore and Benbasat (1991) developed a reliable instrument to measure the constructs within diffusion research. More important than an instrument, Moore and Benbasat (1991) proposed a best practice in instrument development process which could be used not only in IS field but also in other research fields.

Gradually, in order to reach a better understanding of usage acceptance IS scholars employed behavioral theories such as theory of reasoned action (Fishbein and Ajzen, 1975) and theory of planned behavior (Ajzen, 1991) in their theoretical frameworks. Taylor and Todd (1995) proposed the decomposed theory of planned behavior which is the combination of TAM, theory of planned behavior (Ajzen, 1991), and Rogers' diffusion of innovation theory. His findings indicate that the decomposed theory of planned behavior provides a better understanding of behavioral intention by decomposing the beliefs structures such as perceived usefulness, perceived ease of use, compatibility, peer influence, superior's influence, self-efficacy, and etc. in the theory of planned behavior.

Venkatesh and Davis (2000) proposed TAM2 mainly in order to find out the most important determinants of perceived usefulness. Their empirical results indicate that subjective norms, image, job relevance, output quality, and result demonstrability are the most important determinants of perceived usefulness. They

also found that experience and voluntariness moderate the effect of subjective norms on intention to use. Figure 2-2 shows the TAM2 proposed by Venkatesh and Davis.

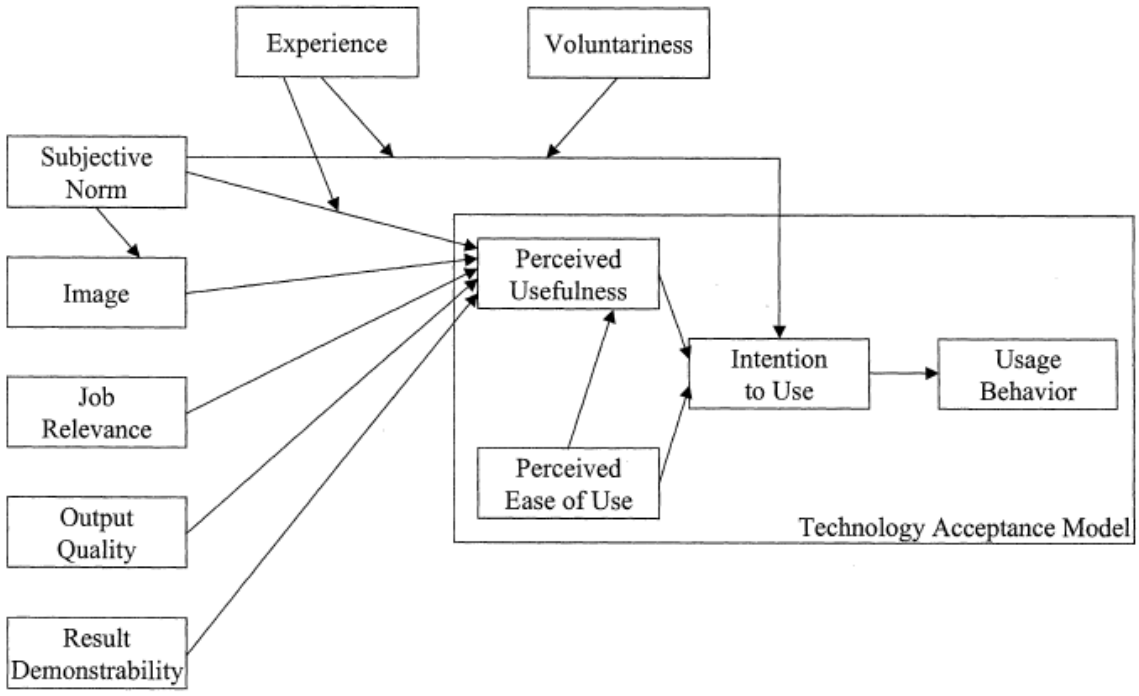

Figure 2-2 TAM2 proposed by Venkatesh and Davis (2000) (source: Venkatesh and Davis, 2000)

Undoubtedly one of the most comprehensive models in user acceptance of information technology is the Unified Theory of Acceptance and Use of Technology (UTAUT) proposed by Venkatesh and his colleagues in 2003. Venkatesh and his colleagues merged eight prominent models and theories including the theory of planned behavior, the innovation diffusion theory, the technology acceptance model (TAM), social cognitive theory, and etc. to develop a model in user acceptance. They defined four constructs including performance, expectancy, effort expectancy, social influence, and facilitating conditions as the most important determinants of behavioral intention and use behavior. They also

found that gender, age, experience and voluntariness of use moderate the relationships between these constructs and behavioral intention and use behavior as shown in figure 2-3. They empirically tested their proposed model and found that this new model explains 70 percent of variance in usage intention which compared to any of the original models that they used was a much better result.

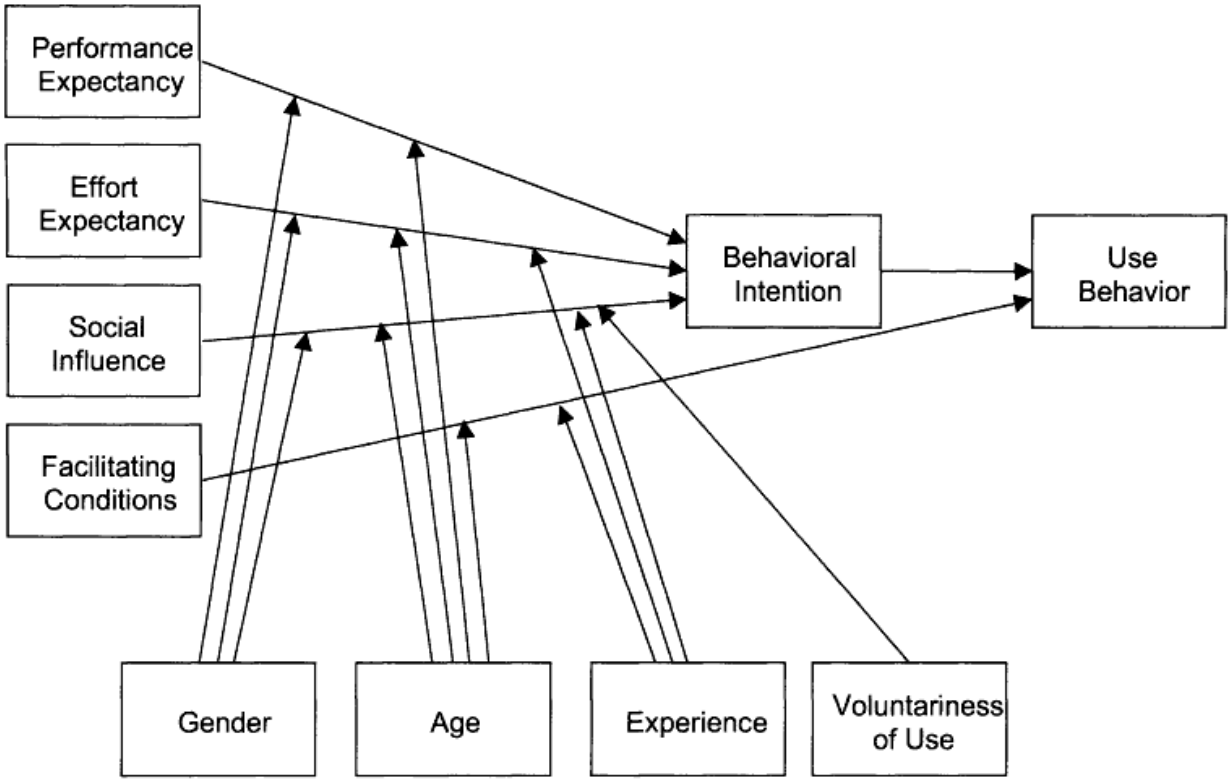

Figure 2-3 Unified Theory of Acceptance and Use of Technology (UTAUT) proposed by Venkatesh and his colleagues in 2003

So far we discussed one research stream in information technology field which concerned about user acceptance of information technology. As we see the IS scholars in this research stream put a lot of effort into developing comprehensive models which can explain the intention behavior and use behavior

of individuals much better than previous one. According to Venkatesh (2003) further research in this field should investigate other potential constructs as well as link this research streams with other research streams in the organizational field. Another research stream in the information technology field still uses the original perceptual variables proposed by Rogers in order to find the most important factors which influence the rate of adoption of new information technologies in different areas such as telecenters in rural areas, internet banking, mobile, e-commerce, and WAP. We review some articles in this research stream in order to get a better understanding of Rogers' diffusion theory impact in IT field.

Gollakota and Doshi (2011) investigated about the diffusion of rural telecenters in the developing world. Their research results indicate that information and knowledge about technology as well as sufficient infrastructure have an important effect on diffusion of telecenters in rural areas in developing countries. In addition, diffusion of telecenters in such areas needs a process which considers the existing traditions and practices, the importance of perceived complexity, and visibility of the use and benefits of the telecenters. Nasri (2011) investigated the factors that influence the adoption of internet banking services in Tunisia. His research results indicate that convenience, risk, security, and prior internet knowledge strongly affect the intention to use. In addition, demographic factors such as occupation and instruction impact significantly internet banking behavior.

In the context of e-commerce, Easten (2002) investigated the adoption of four e-commerce activities: online shopping, online banking, online investing, and electronic payment for an internet service. His research results indicate that six perceived attributes including perceived convenience, perceived financial benefits, risk, the previous use of the telephone for a similar purpose, self-efficacy, and internet use all affect the adoption of those innovations. He also assessed the possible consequences of diffusion of those innovations at individual and social

level. Hung, Ku, and Chang (2003) investigated the diffusion of wireless application protocol (WAP) in Taiwan, using theory of planned behavior and theory of innovation diffusion. Their research findings indicate that connection speed, service costs, user satisfaction, personal innovativeness, ease of use, peer influence, and facilitating conditions affect the adoption of WAP services.

Ollila and Lyytinen (2003) investigated the factors influencing over 200 information system process innovation decisions in three organizations over the past forty years. Their research results indicate that several diffusion of innovation factors including availability of technological infrastructure, past experience, own trial, autonomous work, ease of use, learning by doing and standards, and user need recognition strongly affect the IS process innovations decisions.

3
Research Model and Hypotheses

Figure 3-1 shows our proposed model for diffusion of battery electric vehicles. As we see, eleven variables affect the diffusion of a battery electric vehicle. These variables are: (1) social prestige (2) social pressure to adopt a BEV[3], (3) difficulty of use, (4) knowledge and information about a BEV, (5) price, (6) product performance, (7) product availability, (8) usefulness for environment, (9) perceived risk, (10) fuel cost savings, and (11) financial incentives. From above variables, price, perceived risk, and difficulty of use have negative influence on the rate of adoption of battery electric vehicles and other variables have positive influence on the rate of adoption of battery electric vehicles. As we explained in the introduction of this paper, our research model for diffusion of battery electric vehicle is derived from the main concepts and constructs of theory of diffusion of innovation proposed by Rogers (1962). In Table 3-1 we provide the definition for each variable and the effect of each variable on the rate of BEV adoption.

[3] BEV: Battery Electric Vehicle

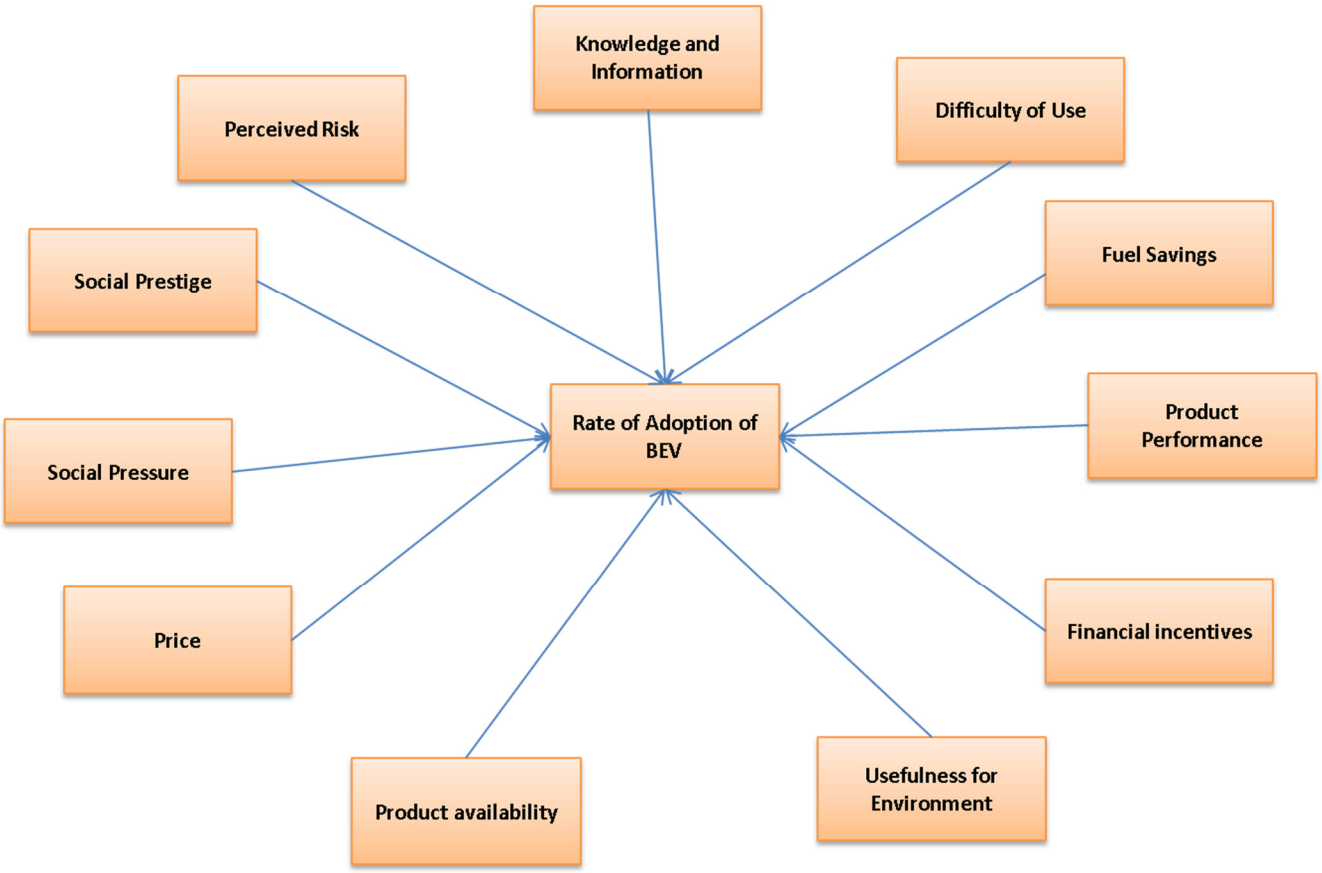

Figure 3-1 Proposed Research Model

Variables	Definition Of Variable	Effect on rate of BEV adoption
Price	The degree to which people perceive the price of a BEV compared to a similar ICEV is higher	Negative
Social Pressure	The degree to which people in a society feel pressure to use a BEV	Positive
Difficulty of Use	the degree to which the use of a battery electric vehicle perceived as relatively difficult	Negative
Knowledge and Information	The degree to which people have the knowledge and information about BEVs	Positive
Perceived Risk	The degree to which people perceive the risks when they intend to buy a BEV	Negative
Product Availability	The degree to which people perceive they can find and buy their desired BEV brand and model in a market	Positive
Usefulness for Environment	The degree to which people perceive the use of a BEV is useful for environment	Positive
Product Performance	The degree to which people perceive the BEV performance is generally better than that of an ICEV	Positive
Social Prestige	The degree to which people feel the social prestige when they use a BEV	Positive
Fuel Cost Savings	The degree to which people perceive the fuel cost savings of using a BEV is considerable	Positive
Financial Incentives	The degree to which people perceive the financial incentives offered by change agents to buy a battery electric vehicle are attractive	Positive
Intention to buy a BEV	The degree to which people intend to buy a BEV	Dependent variable

Table 3-1 Definition of variables and their effect on rate of BEV adoption

Table 3-2 shows the difference between our theoretical framework (DOI theory proposed by Rogers in 1962) and our research model.

As we explained earlier relative advantage in DOI theory has a broad meaning and can be interpreted quite differently. Therefore, we split this variable into 4 variables: price, fuel cost savings, social prestige, and product performance.

In the context of adopting battery electric vehicles, observability is not an important factor because this product is tangible and observability does not make any difference between a battery electric car and an internal combustion engine vehicle. (It is important to notice that in the context of adopting green products we always compare the adopting of green products with non-green products so we are looking for factors which highlight the differences between these two choices) Trialability also does not make any difference because today all products more or less are trialable and consumers can test the products before adopting them.

Regarding complexity, we define the new variable "difficulty of use" and include the complexity in this variable. Compatibility is another factor in original DOI theory that according to Rogers (2003) two factors are important for this factor: consistency with past behavior and consistency with the existing values. We believe that if a new product is inconsistent with past behavior, life style or habits of an individual, the adoption of such new product becomes more difficult and so we include this part of compatibility concept in "difficulty of use" variable.

We excluded the type of innovation-decision factor in DOI theory, as we believe that in the context of adopting battery electric vehicle which is a high involvement product, consumers has freedom to choose any type of vehicle – internal combustion engine vehicle, hybrid, or battery electric vehicle- and no one can force them to buy any specific model.

Regarding communication channels factor in DOI theory, we define the knowledge and information variable in our research model as we believe that in the

context of diffusion of innovation the main function of communication channels including mass media and interpersonal channels is to give information and awareness about new products to consumers. Therefore, by measuring the level of information and knowledge of consumers about the various dimensions of battery electric vehicles, we can measure the functionality of communication channels. Of course, according to Rogers, the second function of communication channels is to give persuasion and motivations to buy an innovation but we excluded the measurement of this function from our research model because this function usually happens when the diffusion of innovation process passes from awareness to motivation phase. We do not believe that this is the case for diffusion of battery electric vehicles because this product is still now at the preliminary stage of diffusion and it takes time that communication channels specifically interpersonal communication gain momentum and their persuasion and motivation function starts producing results.

In order to measure the nature of the social system in DOI theory, we define the social pressure variable. This variable helps us to measure the degree to which social norms and structure in a social system put pressure to members of its system to adopt a battery electric vehicle.

We define the financial incentive variable in our research model in order to measure the extent of change agents' promotional efforts in a society. We measure the perception of respondents about the adequacy of financial incentives offered by change agents. Undoubtedly, regardless of the amount of financial incentives that change agents offer to buy a battery electric vehicle, it is the perception of consumers about the worth of financial incentives which finally motivates them whether to buy a battery electric vehicle or not.

As we explain earlier, the other researchers added perceived risk to Rogers' diffusion of innovation theory (Midgley and Dowling, 1978; Ostlund, 1974). We

believe this factor plays a critical role in diffusion of battery electric vehicles as the lack of enough infrastructure for charging BEVs and the fear that selling used BEV would not be easily possible impose a great risk to consumers and as a result affect negatively the consumers' decision to buy a battery electric vehicle.

Finally, the product availability is another factor that we added to our research model. Rogers assumed that the innovation is available and so he did not include this factor in his DOI theory. We added this variable into our research model because the supply of battery electric vehicles due to dominance of internal combustion engine vehicles in the market is very limited mainly because the big car manufacturers have not yet come to the conclusion that the demand for battery electric vehicles is potentially big enough to start mass production of this type of vehicles. Of course, in addition to demand, infrastructure for charging battery electric vehicles is not ready yet to force manufacturers make a quick decision in this regard.

In the next section, we explain each variable of our model and develop our research hypotheses.

Factors	Original DOI Theory	Our Research Model
Relative advantage	✓	We split relative advantage into price, fuel cost savings, social prestige, and product performance
Compatibility	✓	We included this factor in difficulty of use variable in our model.
Trialability	✓	It is not meaningful in our research context so we exclude it from our research model.
Observability	✓	It is not meaningful in our research context so we exclude it from our research model.
Complexity	✓	We use difficulty of use to cover habits (compatibility) and complexity
Types of innovation decision (optional, collectively, authority)	✓	It is not meaningful in our research context so we exclude it from our research model.
Communication channels (mass media and interpersonal)	✓	The function of communication channels in Rogers' theory is awareness-knowledge and persuasion-motivation. We only covered the first function that is the awareness-knowledge function.
Nature of the social system	✓	We use social pressure as a variable in our research model that represents the nature of social system factor in Rogers' theory.
Extent of change agents' promotional efforts	✓	We include the financial incentive variable to cover this factor in our research model.
Perceived Risk	-	We added this item to our research model based on the literature review.
Product Availability	-	We added this item to our research model based on the literature review.

Table 3-2 Difference between our theoretical framework (DOI Theory proposed by Rogers (1962) and our research model

3.1 Price

We define the price as "the degree to which the price of a battery electric vehicle is higher than that of a similar internal combustion engine vehicle".

Clearly, price plays a very critical factor in consumers' decision to buy a battery electric car. Currently there is a huge difference between the price of a BEV and an ICEV[4]. The change agents such as governments or municipalities try to reduce this price difference by offering various financial incentives such as tax rebate and subsidies. In the context of green products, many researchers found the price of a green product is the main barrier to the widespread use of that green product. Therefore, in the context of battery electric vehicle, we can develop the following hypothesis for this variable:

H1: The higher price of a battery electric vehicle in a market, the less people adopt that battery electric vehicle.

3.2 Social pressure to adopt a BEV

We define the social pressure as "The degree to which people in a society feel pressure to use a BEV". As Rogers explained in his DOI theory, social system affects the diffusion of innovation in several ways. Social norms, communication structure, and change agents are the most important factors in this area which affect the diffusion of an innovation. Because the change agent role in diffusion of green products is critical, we consider this variable as an independent variable and discuss it later. Ajzen (1985) also explained "the subjective norms" concept and defined it as "the extent to which "important others" would approve or disapprove the performing a behavior made by an individual". We believe that all these concepts including social norms, social structure, opinion leaders, types of innovation-decisions, and subjective norms explain one specific factor which is "social pressure to adopt or reject an innovation". We merge all these concepts into

[4] ICEV: Internal Combustion Engine Vehicle

one variable and name it "social pressure". Social norms, friends and other important people around an individual can influence his decision to adopt or reject a battery electric vehicle. We develop the following hypothesis regarding this variable:

H2: the more there is social pressure to adopt a battery electric vehicle in a social system, the more people adopt that battery electric vehicle.

3.3 Difficulty of use

We define the difficulty of use as "the degree to which the use of a battery electric vehicle perceived as relatively difficult". Both "Complexity" in DOI theory and "perceived behavioral control" in TPB[5] are defined as "the extent to which the performing a behavior (for example adopting an innovation) is perceived relatively easy". In line with these variables, we define the difficulty of use as "the degree to which the use of a battery electric vehicle perceived as relatively difficult". We develop the following hypothesis for this variable:

H3: The more people perceive the use of a battery electric vehicle as difficult, the less they adopt that battery electric vehicle.

The factors influencing the difficulty of use include infrastructure, technology, and habits or lifestyle of an individual. Infrastructure is a critical factor in diffusion of green products. For example, adopting electric cars depends heavily on the number of charging stations and capacity of grid in cities. Technology also plays an important role in diffusion of green products. For example, the diffusion of battery electric cars depends strongly on technology advancements in batteries and charging stations. Past behavior, habits and lifestyle can affect the difficulty of

[5] Theory of Planned behavior proposed by Ajzen

use. Sometimes people have to change their habits and lifestyle in order to adopt a new product and it is not very easy for them to change their habits. For example, charging a battery electric car every night is a new task which is not usually compatible with lifestyle of an individual. Therefore, an individual may perceive difficulty when he has to change his routine lifestyle. According to Tornatzky and Klein (1982), complexity had the most consistent significant relationships to innovation adoption. Dickerson and Gentry (1983) found that complexity had the negative influence on adoption across innovations such as personal computers. In an eco-innovation context, complexity had the negative influence on adoption of solar energy systems. (Labay and Kinnear, 1981) Jansson (2010) found that adopters of alternative fuel vehicles (AFVs) perceived AFVs to be less complex than non-adopters.

3.4 Knowledge and information about a BEV

We define the knowledge and information as "The degree to which people have the knowledge and information about BEVs". As Rogers explained in his DOI theory, the knowledge and awareness about an innovation is the first step in innovation-decision process. We believe that the information and knowledge about a green product can positively influence the rate of adoption. Social media and Internet have the key role in providing information and knowledge about green products in a social system. We develop the following hypothesis regarding this variable:

H4: the more people have the knowledge and information about a battery electric vehicle, the more they adopt that battery electric vehicle.

3.5 Perceived risk

We define the perceived risk as "The degree to which people perceive the risks when they intend to buy a BEV". Perceived Risk is another variable can affect the rate of adoption. (Midgley and Dowling, 1978; Ostlund, 1974) In the context of battery electric car, we think that people may perceive a higher risk to buy this type of car compared to ICEVs because of its low reliability, the lack of the required infrastructure, the fear that they cannot resell their used battery electric car, and the lack of familiarity with electric technology. We develop the following hypothesis regarding this variable:

H5: The higher people perceive the risk of using a battery electric vehicle, the less they adopt that battery electric vehicle.

3.6 Product availability

We define the product availability as "The degree to which people perceive they can find and buy their desired BEV brand and model in a market". The availability of various BEV brands and models with different features in a market, helps people can select their desired BEV model and brand and it affects the rate of adoption of BEV in a social system. One of the problems with diffusion of BEVs is that the number of BEV production is very limited so the lack of product availability in a market plays as a barrier to the widespread use of BEVs. We develop the following hypothesis regarding this variable:

H6: The more people perceive they cannot find and buy their desired battery electric vehicle brand and model, the less they adopt that battery electric vehicle.

3.7 Usefulness for environment

We define the usefulness for environment as "The degree to which people perceive the use of a BEV is useful for environment". As Stern (1994) explained in his VBN theory, environmental concerns force people to take responsibility of their actions in a social system and make them feel morally obligated to participate and involve in proenvironmental activities. We believe that people are now more willing to take the responsibility of their actions in a social system regarding the problems such as global warming and air pollution so we develop the following hypothesis for this variable:

H7: The more people perceive that battery electric vehicle is useful for the environment, the more they adopt battery electric vehicles.

3.8 Product performance

We define the product performance as "The degree to which people perceive the BEV performance is generally better than that of an ICEV". Undoubtedly, the vehicle performance is one of the factors that influence the consumers' decision to buy a car. Clearly, when it comes to buy a battery electric car people compare its performance with the similar internal combustion engine vehicle so if the performance of a BEV is not comparable to that of a similar ICEV, they are not going to adopt that battery electric vehicle. Therefore, we develop the following hypothesis:

H8: The more people perceive that performance of a battery electric vehicle is better than that of a similar internal combustion engine vehicle, the more they adopt that battery electric vehicle.

3.9 Social prestige

We define the social prestige as "The degree to which people feel social prestige when they use a BEV". According to Rogers, social prestige can be as a relative advantage when people adopt an innovation. Given the style of battery electric vehicle is differentiate from other types of vehicles and it can easily be noticed by people in the streets, we believe that people feel prestige when they use a battery electric vehicle because it shows that they care about the environment. Therefore, we develop the following hypothesis regarding this variable:

H9: The higher people feel that using a battery electric vehicle is a prestigious behavior, the more they adopt that battery electric vehicle.

3.10 Fuel cost savings

We define the fuel cost savings as "The degree to which people perceive the fuel cost savings of using a BEV is considerable". Fuel cost savings can be part of relative advantage that people seek when they buy a battery electric vehicle. The amount of money people can save by using a battery electric vehicle can be considerable, given the price of oil stays at the current range. The following hypothesis can be developed for this variable:

H10: The higher people perceive the fuel cost savings of using a battery electric car is considerable, the more they adopt that battery electric vehicle.

3.11 Financial incentives

We define the financial incentives as "the degree to which the financial incentives offered by the change agents are attractive to people". As we explained

earlier, we define the financial incentive variable in our research model in order to measure the extent of change agents' promotional efforts in a society. We measure the perception of respondents about the adequacy of financial incentives offered by change agents. Therefore, we develop the following hypothesis regarding this variable:

H11: The higher people perceive the financial incentives offered by change agents to buy a battery electric vehicle are attractive, the more they adopt that battery electric vehicle.

3.12 Intention to buy a battery electric vehicle

We define our dependent variable as "the degree to which people plan or intend to buy a battery electric vehicle as a first or second personal vehicle". We measure the rate of adoption in our model by this variable. The logic behind using this variable to measure the rate of adoption is that there is a correlation between the intention to buy a product and actual behavior. The extensive research on the theory of planned behavior by Ajzen (1981) and the other researchers showed there is strong correlation between the intention to do a behavior and the actual behavior. In the field of diffusion of an innovation researchers have usually used the intention to adopt an innovation in order to measure the rate of adoption of an innovation.

4
Research Methodology

In this chapter, we explain in details our research method which we used for testing our hypotheses. As we said earlier in this document, the nature of our research questions is predictive and we follow a deductive research strategy in our research. The research paradigm is positivism. In the positivism paradigm knowledge should be based on what can be objectively observed and measured, and assumes that observer objectivity is possible. (Williamson, 2002)

In this research we used the quantitative method for data collection, reduction and analysis. This research methodology is completely compatible with our positivism research paradigm and deductive research strategy. According to Blaikie (2009), quantitative methods are generally concerned with counting and measuring aspects of social life. In this research, we tested our hypotheses by counting and measuring responses of individuals based on Likert scale (1 to 7: Strongly disagree to strongly agree) to a set of statements. These statements were created and validated through a process which we call survey instrument development process. In the next section, we are explaining our steps that we took for developing questionnaire, collecting data, and analyzing our data in details.

4.1 Steps for Data Collection

In this research we conducted an online survey, measuring the responses of individuals based on 7-point Likert scale. Our method for data collection is self-administrated questionnaire. According to Rogers (2003), most of the research on rate of adoption of innovation has been conducted by survey method (questionnaire). Tornatzky and Klein (1982) reviewed 75 papers pertaining to diffusion of innovation and found that most of studies employed surveys or interviews to gather data. As a preliminary draft we used the survey instrument (questionnaire) of Jansson (2010). This survey instrument was used to measure the adopters and non-adopters ideas about some specific constructs including relative advantage, complexity, compatibility and etc. in alternative fuel vehicles context. The items in this questionnaire covered some specific constructs in our research and we added more items for the additional constructs which we added to our research model. Our steps for data collection are as follows:

4.1.1 Questionnaire items creation

The aim of this step was to create at least three statements for each construct. We first reviewed all existing items from Jansson (2010) survey instrument and assigned some statements to related constructs. Second, the new items for remaining constructs were created. According to Moore and Benbasat, (1991), for each construct at least one statement should be made to which the respondent will be asked to indicate a degree of agreement or disagreement. The output of this step was the preliminary questionnaire which is attached in the Appendix 1 of this thesis.

4.1.2 Questionnaire items validation

The aim of this step is to ensure the content validity (is the question capturing the characteristics you are trying to measure). In this step, a team of experts including three professors in ITM department in Ted Rogers School of Management, and two Ph.D. students from industrial engineering and marketing field reviewed the questionnaire items to ensure instrument readability and content validity. The output was a new version of questionnaire which was sent to Ryerson Ethics Committee to get the ethics approval.

4.1.3 Applying for ethics review

In this step, the questionnaire was sent to Ryerson Ethics Committee in order to get the approval. The comments of Ethics Committee were applied to whole questionnaire and the Ethics approval was obtained.

4.1.4 Set up an online questionnaire to collect data

In order to collect data, we designed an online survey. We used Qualtrics software to design our online survey. Qualtrics is very famous software for online survey in academia environment and many researched in North America use Qualtrics for conducting their online survey. Qualtrics has its own panel for respondents but we hired a Canadian Company, Canadian viewpoint, to collect data for us in Ontario. Canadian Viewpoint is one of the Canada's leading experts in market research data collection both offline and online. It is a corporate member of the Market Research and Intelligence Association (MRIA).

4.1.5 Running a Pilot test

In this step, a pilot study was conducted on a group of 20 persons through online survey. We selected different people with different background for our

sample including faculty staff, students, engineers and employees. All of them have at least 2 years driving experience and live in Ontario. The feedback of this pilot study was used to check the reliability of the instrument. The table 4-1 shows the inter-item correlations mean and Cronbach's Alpha for the constructs that we used in our research model. For measuring other variables including price, fuel cost savings, and usefulness for environment, we used only one item so we did not need to calculate the Cronbach's Alpha. We used SPSS version 20 for our data analysis.

Construct Name	Number of Items	Inter-item correlations mean	Cronbach's Alpha
Price	1	-	-
Fuel Cost Savings	1	-	-
Usefulness for environment	1	-	-
Social Pressure	3	0.757	0.903
Difficulty of Use	6	0.241	0.645
Knowledge and Information	8	0.611	0.924
Perceived Risk	4	0.478	0.791
Product Availability	3	0.069	0.209
Product Performance	3	0.481	0.761
Social Prestige	3	0.834	0.935
Financial Incentives	3	0.423	0.680
Intention to buy a BEV	3	0.705	0.876

Table 4-1 Instrument reliability check for pilot study

According to Kline (1999) the acceptable Cronbach's Alpha for a reliable instrument should be at least 0.7. Therefore, as we see in table 4-1, we have problems with three constructs including difficulty of use, product availability and financial incentives. We also checked the inter-item total correlations for each item

to make sure that the items' correlations with each other for each construct is acceptable (more than 0.3).

Regarding difficulty of use construct, we had 6 items as follows:

- (1) It takes a long time (hours) to charge a Battery Electric Car.
- (2) The driving range of a Battery Electric Car is NOT enough.
- (3) I think I need to change my everyday life routines when I buy a Battery Electric Car.
- (4) Finding a charging station to charge my Battery Electric Car is easy.
- (5) It is hard to find an auto repair shop that services a Battery Electric Car.
- (6) Before I can drive a Battery Electric Car, I need to learn some driving instructions.

By eliminating the questions number 4 and 6 the overall inter-item correlations means and Cronbach's Alpha increased to 0.394 and 0.712 that is acceptable.

Regarding product availability we had the 3 items as follows:

- (1) There are only a few Battery Electric Car models and brands in the market.
- (2) Typically when I want to buy a car I need to compare several models and brands in market.
- (3) I feel I can find my favorite brand and model if I want to buy a Battery Electric Car.

We had to eliminate the question 2 and 3 from our model and only kept the first question in order to be able to measure this variable.

Regarding financial incentives construct, we had 3 items in our questionnaire as follows:

- (1) I think the current financial incentives and subsidies for buying a Battery Electric Car are enough.
- (2) The current financial incentives and subsidies for buying a Battery Electric Car are NOT motivating.
- (3) I need more financial incentives and subsidies to buy a Battery Electric Car.

Although the Cronbach's Alpha for this construct was less than 0.7, we decided to keep all items as they are and check the Cronbach's Alpha for this construct in final data collection phase to make a final decision about this construct.

Table 4-2 shows the revised table for measuring the reliability of our research instrument.

Construct Name	Number of Items	Inter-item correlations mean	Cronbach's Alpha
Price	1	-	-
Fuel Cost Savings	1	-	-
Usefulness for environment	1	-	-
Product Availability	1	-	-
Social Pressure	3	0.757	0.903
Difficulty of Use	4	0.394	0.712
Knowledge and Information	8	0.611	0.924
Perceived Risk	4	0.478	0.791
Product Performance	3	0.481	0.761
Social Prestige	3	0.834	0.935
Financial Incentives	3	0.423	0.680
Intention to buy a BEV	3	0.705	0.876

Table 4-2 Revised instrument reliability check for pilot study

4.1.6 Finalizing the survey questionnaire

After conducting a pilot test, we made the required modifications and finalized our research questionnaire. The final questionnaire is attached in appendix 2 of this thesis. In final questionnaire, we added one more item to the difficulty of use construct in order to have a better understanding of this construct. This item is "There are not enough charging stations in cities"

As it can be seen, we added some other constructs to our questionnaire such as attitude toward using battery electric vehicles, caring about environment, taking the responsibility of our actions against the environment, moral obligations to use battery electric vehicles and some general questions regarding the desired charging time of a typical battery electric vehicle and the extra price that we are willing to

pay to buy a battery electric vehicles. These constructs are not related to our research model but we will analyze them in order to get a better understanding of factors that affects the rate of adoption of battery electric vehicles. We checked the reliability of these constructs too and the results are attached in appendix 3 of this thesis.

Construct Name	Number of Items	Number of cases	Inter-item correlations mean	Cronbach's Alpha
Responsibility	3	20	0.633	0.812
Moral obligations	3	20	0.771	0.909
Attitude	3	20	0.711	0.874

Table 4-3 Reliability check for the constructs not used in our research model (pilot study)

4.2 Data Analysis method

In this research, we are using the factor analysis in order to check the convergent and discriminant validity of our instrument and multiple regression technique to test our hypothesis and find the relative importance of each factor on the rate of adoption of battery electric vehicles. We use the SPSS software version 20 for our data analysis.

4.2.1 Factor analysis

In order to check the convergent and discriminant validity of our research instrument and reduce the factors in our model, we will perform a factor analysis, using principal components method with varimax rotation method. Factor analysis is a good technique in order to find a meaningful and or interpretable grouping of the questionnaire items. (Kositanurit, Ngwenyama and Osei-Bryson, 2006) It will

help us to look for overlapping constructs and cross loading of each questionnaire items.

4.2.2 Multiple regression technique

In order to test our hypotheses, we use the multiple regression technique. The multiple regression analysis is a method of predicting the outcome or dependent variable from several predictor or independent variables. It helps us to find not only the significance of the relationships between independent and dependent variables but also the relative importance of independent variables which is the main goal of this research.

5
Data Collection and Analysis

In this chapter we explain our data collection method and conduct a data analysis including descriptive analysis for each variable, final instrument reliability analysis, factor analysis for confirmatory purposes and instrument convergent and discriminant validity test, and multiple regression analysis for testing our hypothesis. At the end of this chapter we will discuss our research results and findings.

5.1 Data collection

As we explained in chapter 4, we launched an online survey using Qualtrics software to collect data. We hired a market research company to collect data for us in Ontario province. The total number of responses that we collected was 434. The quality of data in online survey is a great concern for all researchers. In order to check the quality of data in our research, we asked a simple question in the middle of the questionnaire as follows: “If you are still paying attention to this questionnaire please select the “strongly agree” choice”. More than 120 responses failed to answer this question correctly which automatically excluded from our database. The other criteria that we used to accept the responses include the current

location of living and the minimum driving experience. In total, from 434 responses, the 310[6] responses were acceptable. Therefore, we had the response rate of about 70 percent. Regarding the adequacy of sample size, we assessed the required sample size from different points. In general, the sample size is a function of Alpha (type-1 error), Beta (type-2 error), and effect size. Given the required Alpha of 0.05, the Beta of 0.05 and the effect size of 0.3, the sample size we need to test our hypotheses is about 260-300. From the factor and regression analysis point of view, we need at least 300 responses to be able to conduct a reliable factor and regression analysis.

5.2 Descriptive analysis

In this section, we conduct a descriptive analysis for each variable including mean, standard deviation and frequency analysis.

5.2.1 Data sample characteristics

Table 5-1 shows our sample characteristics including age, gender, education level, and living status. All participants in this research live in province of Ontario, and have a valid driving license, and at least one year driving experience. 8.1% of participants experienced driving an electric car (hybrid, battery, etc.) for more than 3 months and 4.2% of participants currently own an electric car.

[6] Depending on analysis method which was employed, the number of acceptable responses is different.

Sample Characteristics	Size	Percent
Age		
18-24	15	4.8
25-39	95	30.6
40-50	70	22.6
50+	130	41.9
Total	310	100
Gender		
Male	183	59
Female	127	41
Total	310	100
Education		
Less than High School	10	3.2
High School degree/GED	54	17.4
Some College	93	30
Associate degree	45	14.5
Bachelor's degree (BA, BS)	81	26.1
Master's or Doctoral degree (for example: MA, MS, MEng, MEd, MSW, MBA, PhD)	18	5.8
Professional degree (for example: MD, DDS, JD)	9	2.9
Total	310	100
Living Status		
Single (1 person)	58	18.7
With a Family (2 people)	114	36.8
With a Family (3-5 people)	112	36.1
With a Family (5+ people)	16	5.2
Other (For example: with a roommate)	10	3.2
Total	310	100

Table 5-1 Data sample characteristics (age, gender, education, and living status)

5.2.2 Knowledge and information about BEV

Table 5-2 shows the mean and standard deviation of the amount of relative knowledge people have about battery electric vehicles including the knowledge about the benefits of BEVs for environment (KW1-ENV), the general knowledge about how a battery electric vehicle works (KW2-HIT), the knowledge about cost fuel cost savings gained from using a BEV (KW3-CFS), the knowledge about the available BEV models and brands in the North America market (KW4-MOD), the knowledge about the price range of BEVs in the North America market (KW5-PRI), the knowledge about the financial incentives currently offered by Ontario government for buying a BEV (KW6-INC), the knowledge about the performance attributes of a typical BEV (KW7-PER), and the knowledge about the charging time and available options for charging a BEV (KW8-CHAR). As it can be seen in figure 5-1, people have the little information and knowledge about the BEV financial incentives offered by the government of Ontario, the price range of BEVs, the charging time of BEV, the performance of a typical BEV, and the available BEV models and brands in the market.

Regarding the respondents' knowledge and information about BEVs, the following information can be drawn from the figure 5-1:

- *About 60 to 75 percent of respondents have very little knowledge and information about BEV price, financial incentives offered by Ontario government, BEV performance, BEV models and brands in the market, and BEV average charging time.*

Descriptive Statistics

	N	Mean	Std. Deviation
KW1 ENV-BEN	308	4.13	1.594
KW2 HOW-WORKS	308	3.67	1.644
KW3 COST-SAVINGS	308	4.16	1.653
KW4 MODELS AND BRANDS	307	3.07	1.753
KW5 PRICE RANGE	307	2.82	1.648
KW6 FIN-INCEN	308	2.47	1.551
KW7 PERFORMANCE	307	2.89	1.702
KW8 CHARGING	307	2.94	1.667
Valid N (listwise)	307		

Table 5-2 Descriptive analysis for Knowledge and Information Variable

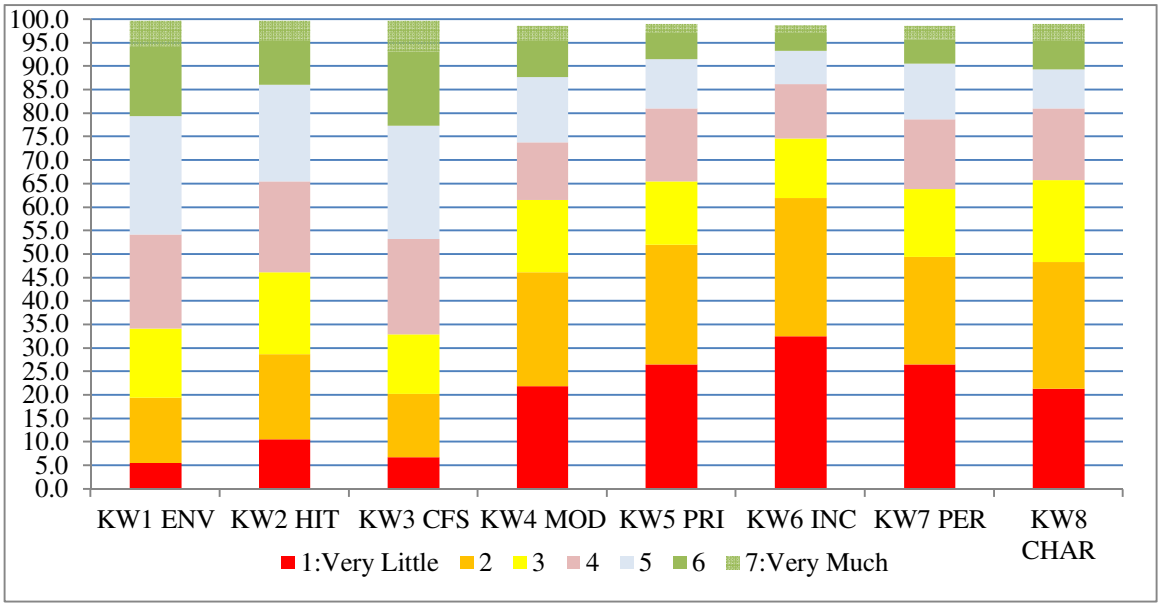

Figure 5-1 Analysis of respondents' knowledge and information about BEVs

5.2.3 Price

Table 5-3 shows the mean and standard deviation of responses to the two questions regarding the price of BEV. These questions are as follows:

- I think the price of BEV compared to that of the similar conventional car is high
- How much are you willing to pay more to buy a BEV than a conventional car?

Regarding the respondents' belief and perception about the price of a typical BEV, the following information can be drawn from the figure 5-2 and 5-3:

- *About 85 percent of respondents think the price of a typical BEV is somewhat higher, higher or much higher than that of a conventional car.*
- *About 90 percent of respondents are not willing to pay more than $3000 more money to buy a BEV than a similar conventional car.*

Descriptive Statistics

	N	Mean	Std. Deviation
PRICE	308	5.43	1.223
PAYING MORE	308	2.52	1.535
Valid N (listwise)	308		

Table 5-3 Descriptive analysis for price

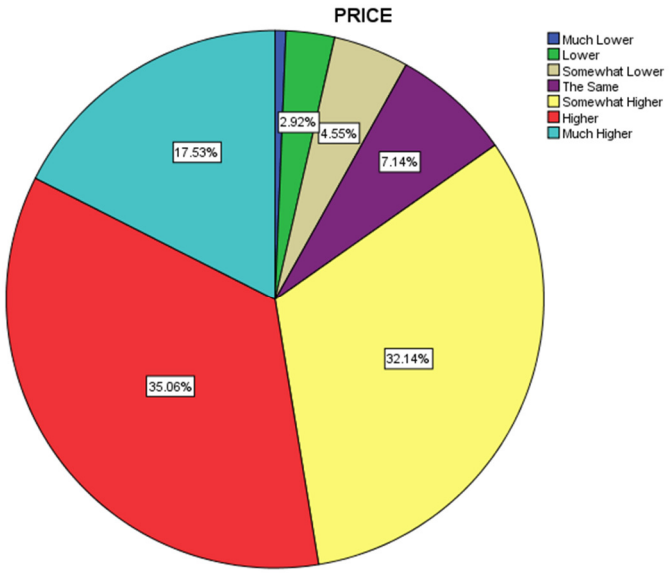

Figure 5-2 Perception of respondents about the price difference between a BEV and a similar ICEV

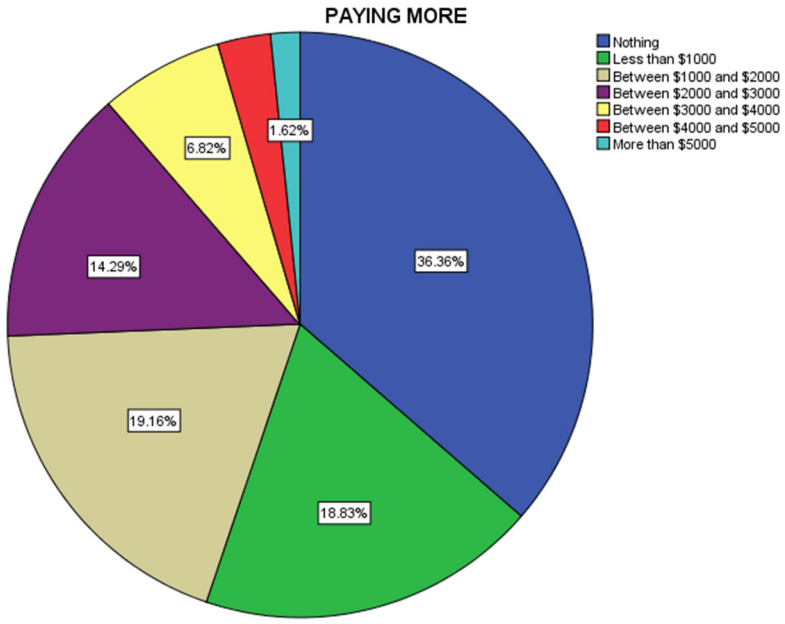

Figure 5-3 Degree to which respondents are willing to pay more money to buy a BEV

5.2.4 Financial Incentives

Table 5-4 shows the mean and standard deviation of responses to the three questions regarding the financial incentives offered by Ontario government to buy a BEV. These questions are as follows:

- I think the current financial incentives and subsidies for buying a Battery Electric Car are enough. (FIN INCENTIVE 1)
- The current financial incentives and subsidies for buying a Battery Electric Car are NOT motivating. (FIN INCENTIVE 2NE)
- I need more financial incentives and subsidies to buy a Battery Electric Car. (FIN INCENTIVE 3NE)

Regarding the respondents' perception about the financial incentives offered by Ontario government to buy a BEV, the following information can be drawn from Figure 5-4:

- *About 75 percent of respondents need more financial incentives and subsidies to buy a BEV.*
- *About 50 percent of respondents believe that the current financial incentives and subsidies are not motivating.*
- *Only about 10 percent of respondents believe that the current financial incentives and subsidies are enough to buy a BEV.*

Descriptive Statistics

	N	Mean	Std. Deviation
FIN INCENTIVE 1	308	3.51	1.236
FIN INCENTIVE 2NE	308	3.30	1.123
FIN INCENTIVE 3NE	308	2.75	1.145
Valid N (listwise)	308		

Table 5-4 Descriptive analysis for Financial Incentives variable

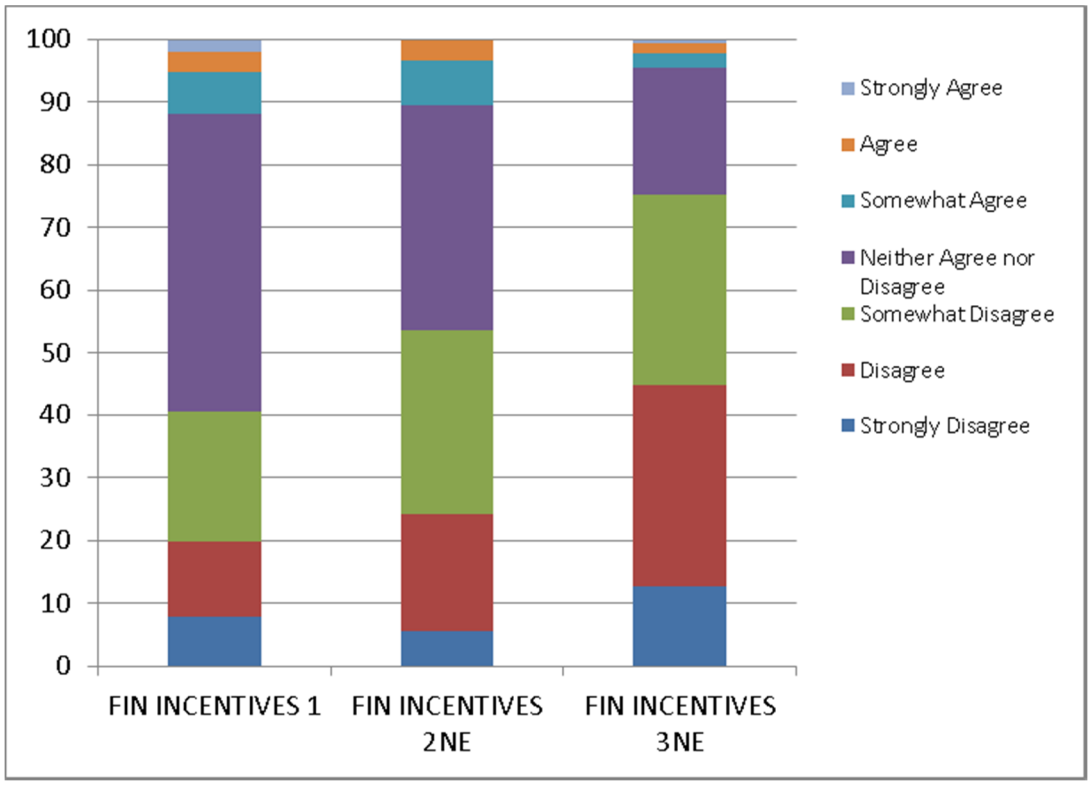

Figure 5-4 Analysis of respondents' perception about available financial incentives and subsidies to buy a BEV in Ontario

5.2.5 Perceived Risk

Table 5-5 shows the mean and standard deviation of responses to the four questions regarding the perceived risk of using a BEV. These questions are as follows:

- I fear I have to pay more money for maintenance of a Battery Electric Car than a similar Conventional Car. (RISK 1)
- I fear that I CANNOT sell easily a used Battery Electric Car when I like to buy a new car. (RISK 2)
- I fear that a Battery Electric Car does not perform well. (RISK 3)
- I fear that I CANNOT charge a Battery Electric Car when I need to charge it. (RISK 4)

Regarding the respondents' perception about the perceived risk of using a BEV, the following information can be drawn from Figure 5-5:

- *About 60 percent of respondents feel risk about maintenance, reselling and the possibility of charging a BEV when it is needed.*
- *About 45 percent of respondents feel risk about the BEV performance.*
- *Only about 10 to 25 percent of respondents believe that there is no or a little risk to use a BEV.*

Descriptive Statistics

	N	Mean	Std. Deviation
RISK 1 MAINTENANCE	308	4.90	1.289
RISK 2 SELLING	308	4.83	1.279
RISK 3 FAILURE	308	4.26	1.355
RISK 4 CHARGING	308	4.84	1.466
Valid N (listwise)	308		

Table 5-5 Descriptive analysis for Perceived Risk variable

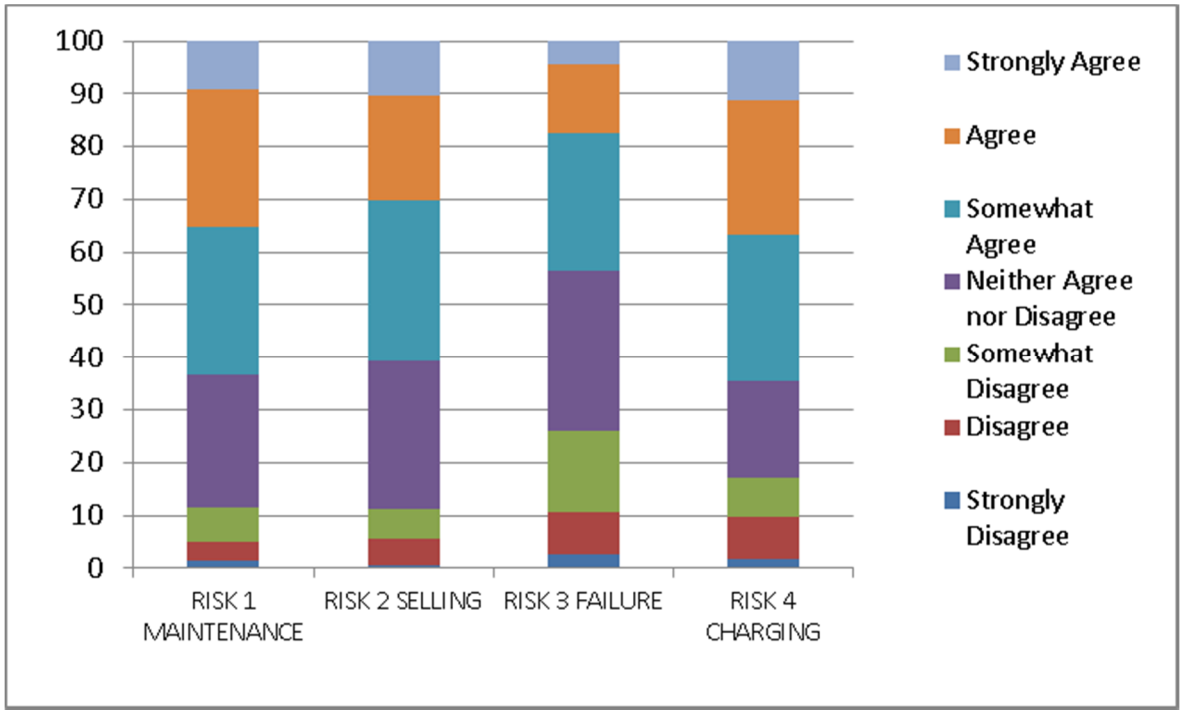

Figure 5-5 Analysis of respondents' perception about perceived risk of using a BEV

5.2.6 Difficulty of use

Table 5-6 shows the mean and standard deviation of responses to the six questions regarding the difficulty of using a BEV. These questions are as follows:

- It takes a long time to charge a Battery Electric Car. (DIF 1)
- The driving range of a Battery Electric Car is NOT enough. (DIF 2)
- I think I need to change my everyday life routines when I buy a Battery Electric Car. (DIF 3)
- Finding a charging station to charge my Battery Electric Car is easy. (DIF 4)
- There are not enough charging stations in cities. (DIF 5)
- It is hard to find an auto repair shop that services a Battery Electric Car. (DIF 6)

Regarding the respondents' perception about the difficulty of using a BEV, the following information can be drawn from Figure 5-6:

- *On average, about 62 percent of respondents perceive the use of a BEV as difficult.*
- *On average, about 10 percent of respondents perceive the use of a BEV as NOT difficult.*

Descriptive Statistics

	N	Mean	Std. Deviation
DIF 1 LONG CHARGING TIME	308	4.56	1.141
DIF 2 RANGE	308	5.16	1.216
DIF3 ROUTINES	308	4.57	1.303
DIF 4 FINDING N	308	5.09	1.418
DIF 5 CHARGING STATIONS	308	5.47	1.264
DIF 6 REPAIR	308	4.92	1.232
Valid N (listwise)	308		

Table 5-6 Descriptive analysis of Difficulty of Use variable

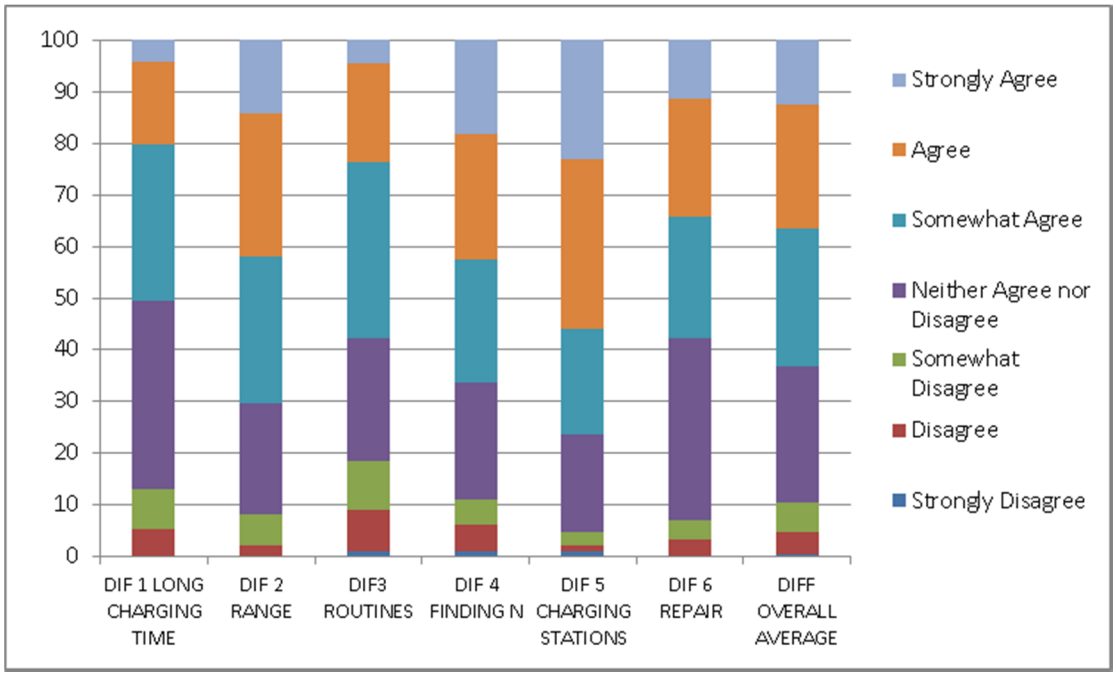

Figure 5-6 Analysis of respondents' perception about difficulty of using a BEV

In addition to these questions, we asked the following question from the respondents in order to understand their view about the acceptable charging time duration to recharge a BEV at home:

- The longest time to fully recharge the battery (at home) that I would consider acceptable is?

As it can be drawn from the figure 5-7, for 60 percent of respondents the 4 hours and less charging time to recharge a BEV at home is acceptable.

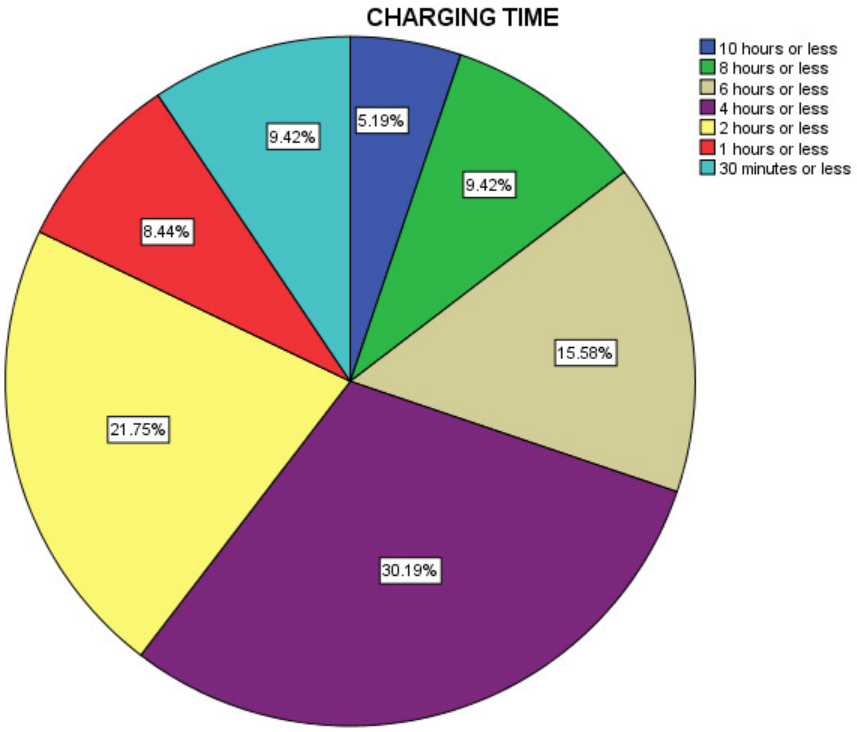

Figure 5-7 Acceptable charging time duration to recharge a BEV at home

5.2.7 Social Pressure

Table 5-7 shows the mean and standard deviation of responses to the three questions regarding the social pressure to use a BEV. These questions are as follows:

- People that mean a lot to me think that I should use a Battery Electric Car instead of a Conventional Car. (SOC PRE 1)
- People close to me think that I should replace my car with a Battery Electric Car. (SOC PRE 2)
- People that are important to me expect me to use a Battery Electric Car instead of a Conventional Car. (SOC PRE 3)

Regarding the respondents' perception about the extent to which there is a social pressure to use a BEV, the following information can be drawn from Figure 5-8:

- *On average, about 70 percent of respondents feel no pressure to use a BEV from the people who are close, important or mean a lot to them.*
- *On average, about 5 percent of respondents feel the pressure to use a BEV from the people who are close, important or mean a lot to them.*

Descriptive Statistics

	N	Mean	Std. Deviation
SOC PRE 1	308	2.71	1.362
SOC PRE 2	308	2.59	1.327
SOC PRE 3	308	2.49	1.280
Valid N (listwise)	308		

Table 5-7 Descriptive analysis for Social Pressure variable

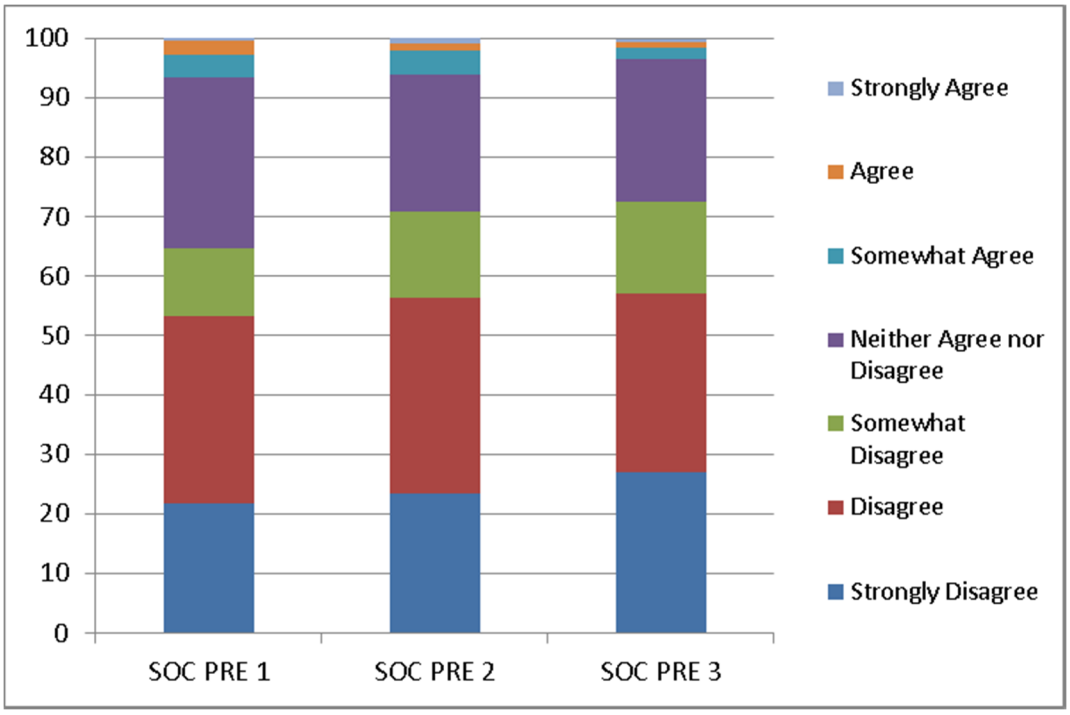

Figure 5-8 Analysis of respondents' perception about the social pressure to use a BEV

5.2.8 Social Prestige

Table 5-8 shows the mean and standard deviation of responses to the three questions regarding the extent to which they would feel social prestige if they use a BEV. These questions are as follows:

- I think I would feel more social prestige if I use a Battery Electric Car. (SOC PRES 1)
- I think I gain a social status if I use a Battery Electric Car. (SOC PRES 2)
- I would feel so proud of myself when I use a Battery Electric Car. (SOC PRES 3)

Regarding the respondents' perception about the social prestige they would feel if they use a BEV, the following information can be drawn from Figure 5-9:

- *About 45 percent of respondents would feel so proud of themselves when they use a BEV.*
- *On average, about 48 percent of respondents would feel no social prestige or gain a social status if they use a BEV.*
- *On average, about 25 percent of respondents would feel social prestige or gain a social status if they use a BEV.*

Descriptive Statistics

	N	Mean	Std. Deviation
SOC PRES 1	308	3.47	1.599
SOC PRES 2	308	3.25	1.586
SOC PRES 3	308	4.20	1.647
Valid N (listwise)	308		

Table 5-8 Descriptive analysis for Social Prestige variable

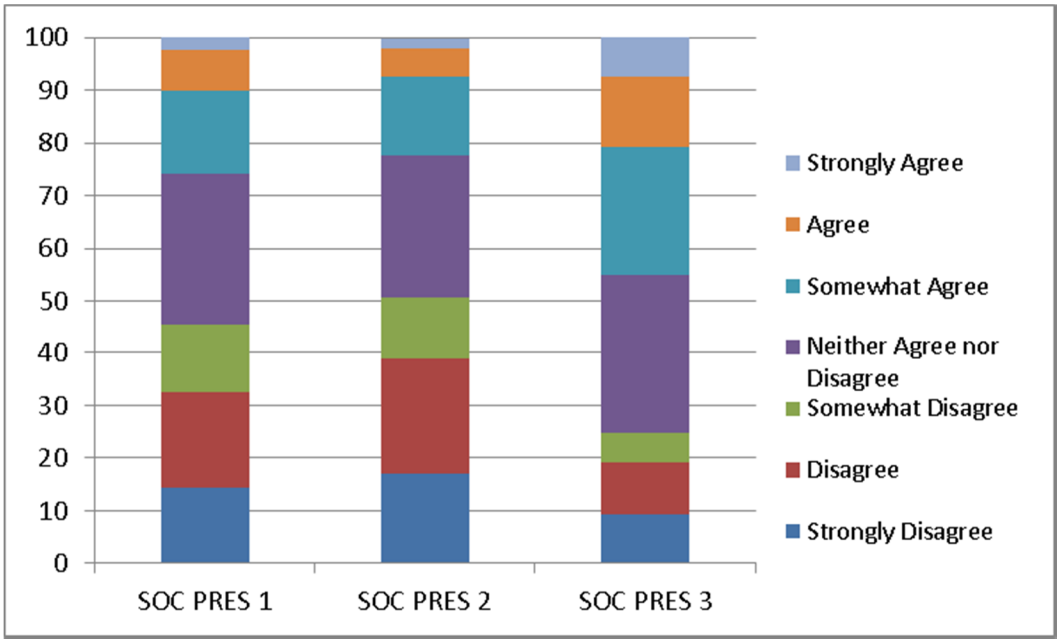

Figure 5-9 Analysis of respondents' perception about the social prestige they would feel if they use a BEV

5.2.9 Product Performance

Table 5-9 shows the mean and standard deviation of responses to the three questions regarding the product performance of a BEV. These questions are as follows:

- I think the performance of a Battery Electric Car is at least the same as its similar Conventional Car. (PERFORMANCE 1)
- I think performance of a Battery Electric Car may NOT be good. (PERFORMANCE 2NE)
- Performance of a car (Acceleration, power, safety and etc.) is very important to me when I want to buy a car. (PERFORMANCE 3G)

Regarding the respondents' perception about the performance of a typical BEV, the following information can be drawn from Figure 5-10:

- *About 88 percent of respondents believe that the performance a car is very important for them when they want to buy a car.*
- *On average, about 31 percent of respondents believe that the performance of a typical BEV is good and comparable with performance of a similar conventional car.*
- *On average, about 41 percent of respondents believe that the performance of a typical BEV may not be good and comparable with performance of a similar conventional car.*

Descriptive Statistics

	N	Mean	Std. Deviation
PERFORMANCE 1	308	3.85	1.373
PERFORMANCE 2NE	308	3.88	1.328
PERFORMANCE 3 G	308	5.68	1.105
Valid N (listwise)	308		

Table 5-9 Descriptive analysis for BEV PERFORMANCE variable

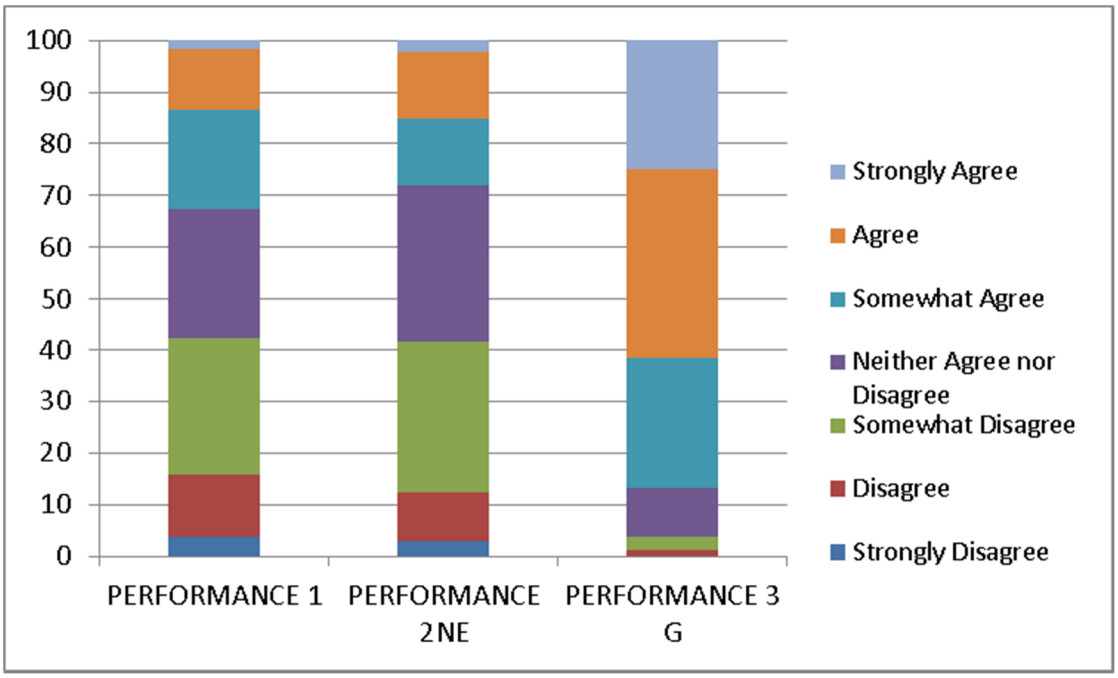

Figure 5-10 Analysis of respondents' perception about the BEV performance

5.2.10 Usefulness for environment

Table 5-10 shows the mean and standard deviation of responses to the question regarding the usefulness of using a BEV for the environment. This question is as follows:

- I believe using a Battery Electric Car is useful for environment.

In addition, we asked the respondents the following question:

- I really care about the environment and try to save it from air pollution.

Regarding the respondents' belief about the usefulness of BEVs for the environment and the extent to which they care about the environment, the following information can be drawn from Figure 5-11:

- *About 88 percent of respondents believe that the use of BEVs is useful for environment.*
- *About 85 percent of respondents care about the environment and try to save it from air pollution.*

Descriptive Statistics

	N	Mean	Std. Deviation
ENVIRONMENT	308	5.55	1.216
CARE	308	5.42	1.088
Valid N (listwise)	308		

Table 5-10 Descriptive analysis for Usefulness for environment and caring about environment

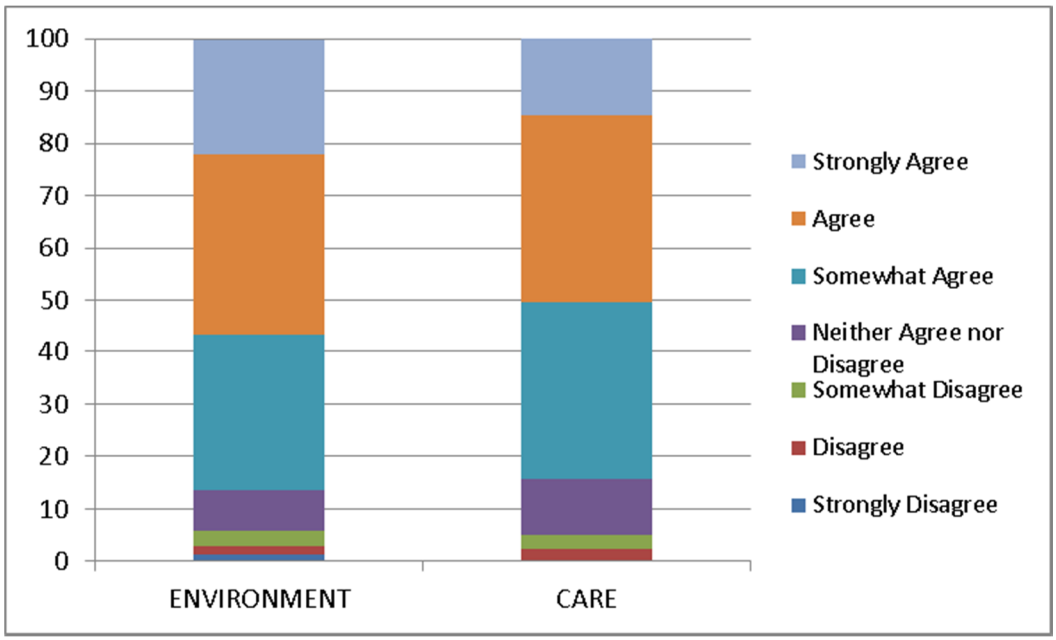

Figure 5-11 Analysis of respondents' belief about the usefulness of BEVs for environment and the extent to which they care about the environment

5.2.11 Product availability

Table 5-11 shows the mean and standard deviation of responses to the three questions regarding the availability of BEV models and brands in the market. These questions are as follows:

- There are only a few Battery Electric Car models and brands in the market.
- I feel I can find my favorite brand and model if I want to buy a Battery Electric Car.
- Typically when I want to buy a car I need to compare several models and brands in market.

As we explained in chapter 4, due to the lack of reliability for this construct we only take into account the responses to the first question to investigate the effect of this variable on the rate of BEV adoption. Regarding the respondents' belief about the availability of BEV models and brands in the market, the following information can be drawn from Figure 5-12:

- *About 78 percent of respondents believe that there are only a few BEV models and brands in the market.*
- *About 85 percent of respondents need to compare several models and brands in market when they want to buy a car.*

Descriptive Statistics

	N	Mean	Std. Deviation
MODEL 1	308	5.13	1.070
MODEL 2N	308	4.27	1.344
MODEL 3 G	308	5.61	1.090
Valid N (listwise)	308		

Table 5-11 Descriptive analysis for BEV Availability in the market

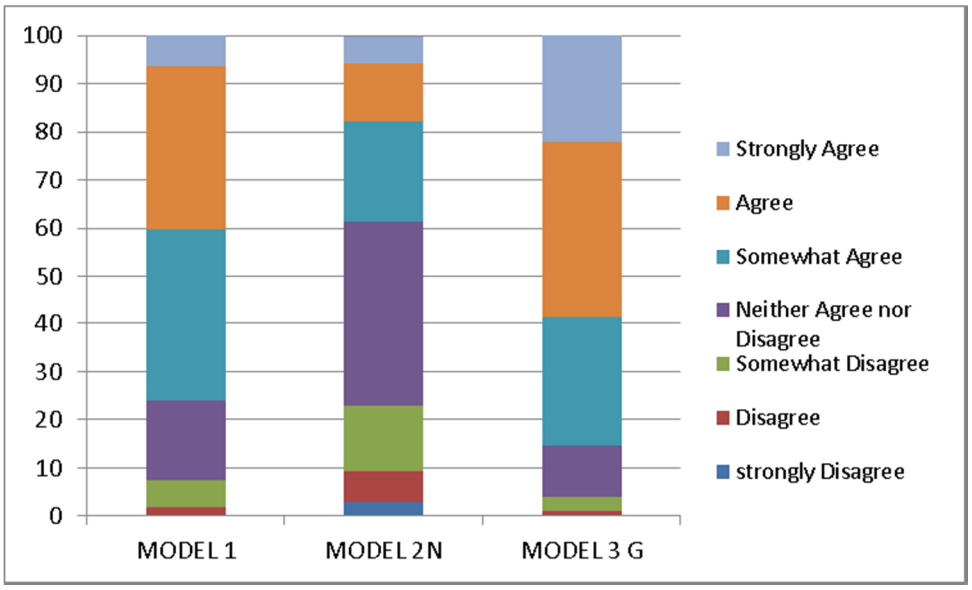

Figure 5-12 Analysis of respondents' belief about the BEVs availability in the market

5.2.12 Fuel Cost Savings

Table 5-12 shows the mean and standard deviation of responses to the two questions regarding the perception of respondents about the fuel cost savings that they gain if they use a BEV and the importance of fuel efficiency when they want to buy a car. These questions are as follows:

- I think I gain good fuel cost savings if I use a Battery Electric Car. (FCS 1)
- Fuel efficiency is very important for me when I want to buy a car. (FCS 2)

Regarding the perception of respondents about the fuel cost savings that they gain if they use a BEV and the importance of fuel efficiency when they want to buy a car, the following information can be drawn from Figure 5-13:

- *About 85 percent of respondents believe that they gain a good fuel cost savings if they use a BEV.*
- *About 91 percent of respondents believe that the fuel efficiency is very important for them when they want to buy a car.*

Descriptive Statistics

	N	Mean	Std. Deviation
FCS1	308	5.42	1.060
FCS 2	308	5.89	1.028
Valid N (listwise)	308		

Table 5-12 Descriptive analysis for Fuel cost Savings variable

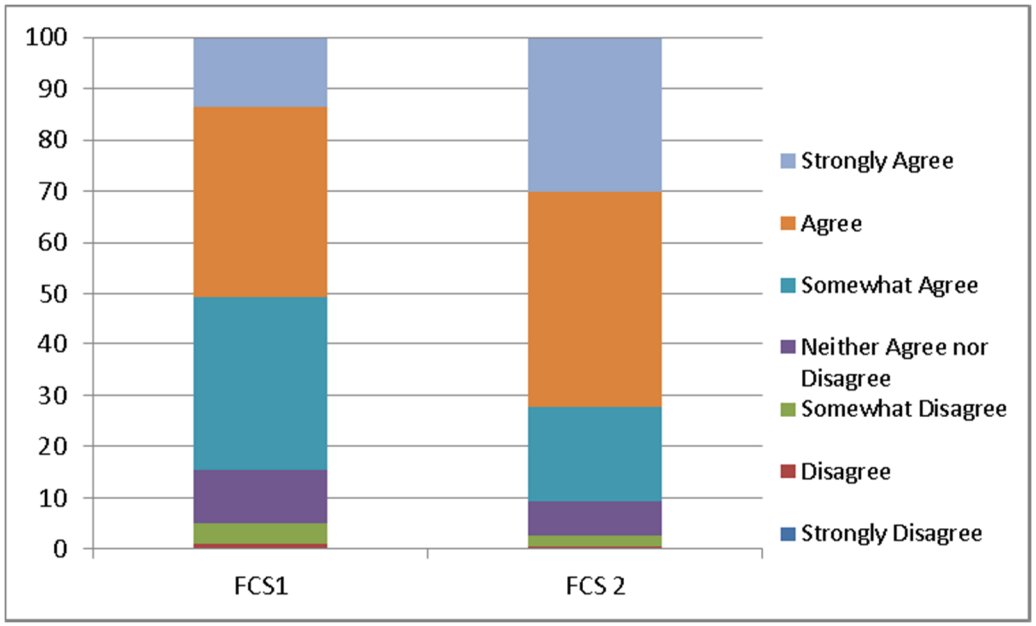

Figure 5-13 Analysis of respondents' belief about the BEVs fuel cost savings and the importance of fuel efficiency when they want to buy a car

5.2.13 Feeling responsibility for the environment

Table 5-13 shows the mean and standard deviation of responses to the three questions regarding the feeling responsibility for the environment. These questions are as follows:

- I am partly responsible for the fossil oil problems in society today.
- I feel partly responsible for the increase in the use of fossil fuels such as oil/gasoline/diesel.
- I feel partly responsible for global warming.

Regarding the respondents' belief about the extent to which they feel responsible for the environment, the following information can be drawn from Figure 5-14:

- *On average, about 60 percent of respondents feel they are responsible for fossil oil problems, increase in the use of fossil fuels, and global warming in society.*
- *On average, about 20 percent of respondents feel they are not responsible for fossil oil problems, increase in the use of fossil fuels, and global warming in society.*

Descriptive Statistics

	N	Mean	Std. Deviation
RESP 1	308	4.87	1.426
RESP 2	308	4.54	1.541
RESP 3	308	4.43	1.585
Valid N (listwise)	308		

Table 5-13 Descriptive analysis for Feeling Responsibility variable

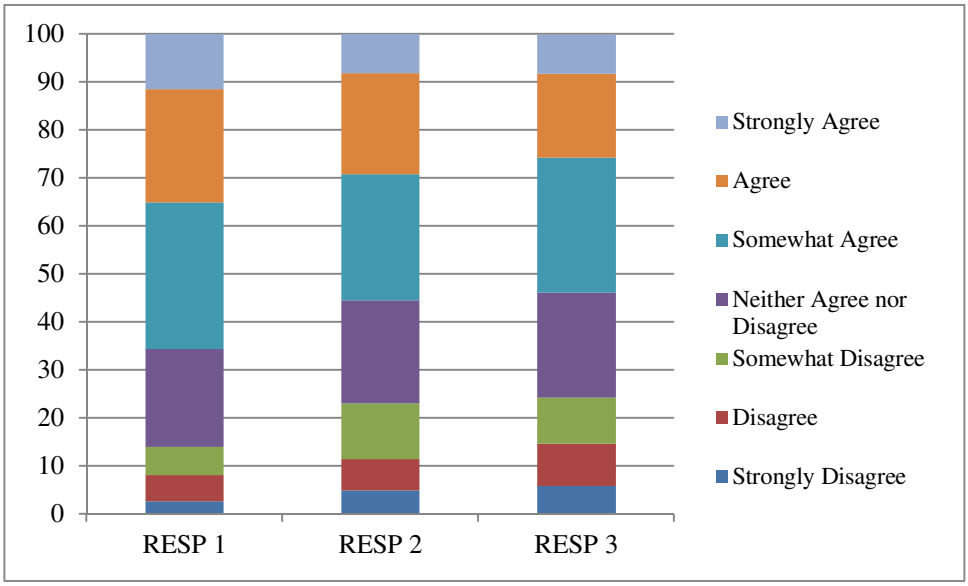

Figure 5-14 Analysis of respondents' belief about the extent to which they feel responsibility for the environment

5.2.14 Moral Obligations to use a BEV

Table 5-14 shows the mean and standard deviation of responses to the three questions regarding the extent to which respondents feel moral obligations to use a BEV. These questions are as follows:

- I feel a moral obligation to use a Battery Electric Car.
- I would be a better person if I used a Battery Electric Car.
- If I were to replace my car today I would feel a moral obligation to replace it for a Battery Electric Car.

Regarding the extent to which respondents feel moral obligations to use a BEV, the following information can be drawn from Figure 5-15:

- *Averagely, about 25 percent of respondents feel moral obligations to use a BEV.*
- *Averagely, about 45 percent of respondents feel no moral obligations to use a BEV.*

Descriptive Statistics

	N	Mean	Std. Deviation
MORAL OBL 1	308	3.52	1.583
MORAL OBL 2	308	3.60	1.744
MORAL OBL 3	308	3.27	1.640
Valid N (listwise)	308		

Table 5-14 Descriptive analysis for Moral Obligation variable

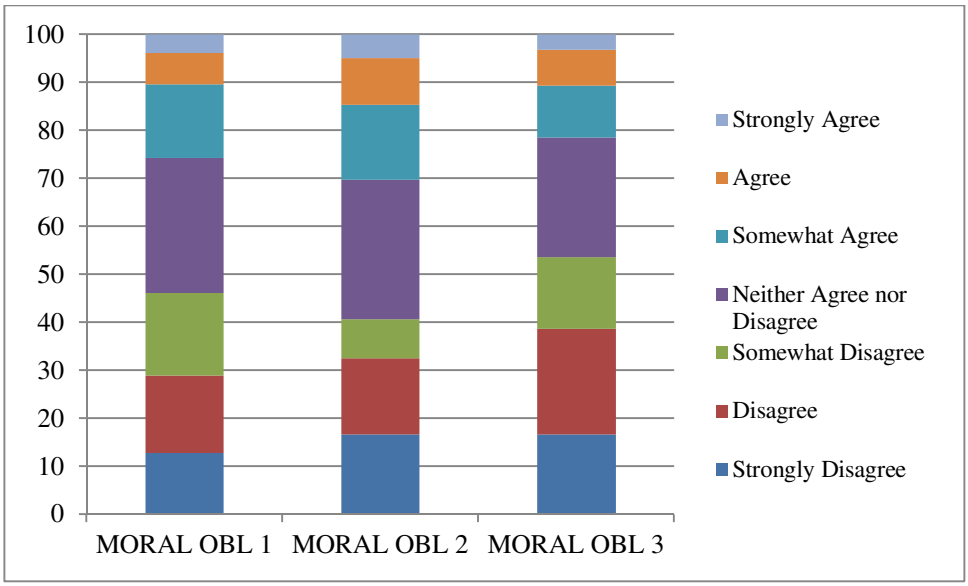

Figure 5-15 Analysis of respondents' belief about the extent to which they feel moral obligations to use a BEV

5.2.15 General attitude toward using a BEV

Table 5-15 shows the mean and standard deviation of responses to the three questions regarding the general attitude toward using a BEV. These questions are as follows:

- For me, to use a Battery Electric Car is pleasant.
- My attitude toward using a Battery Electric Car is positive.
- I like to use a Battery Electric Car.

Regarding the general attitude toward using a BEV, the following information can be drawn from Figure 5-16:

- *Averagely, about 43 percent of respondents like to use a BEV or would feel pleasant to use a BEV.*
- *About 70 percent of respondents indicated that they have positive attitude toward using a BEV.*
- *Averagely, only about 12 percent of respondents do not like to use a BEV, would not feel pleasant to use a BEV or do not have positive attitude toward using a BEV.*

Descriptive Statistics

	N	Mean	Std. Deviation
ATT 1	308	4.44	1.216
ATT 2	308	4.89	1.300
ATT 3	308	4.46	1.342
Valid N (listwise)	308		

Table 5-15 Descriptive analysis for Attitude toward using a BEV variable

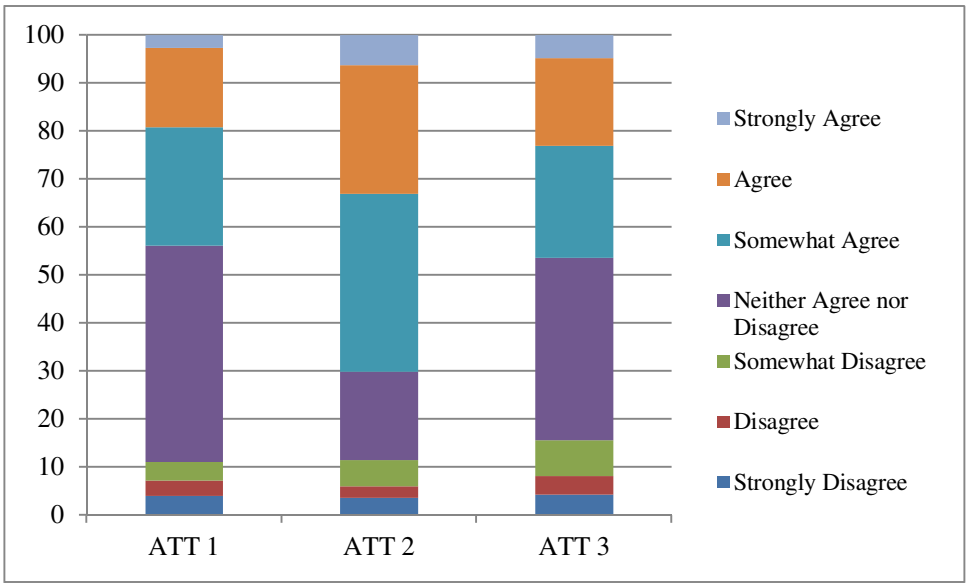

Figure 5-16 Analysis of respondents' attitude toward using a BEV

5.2.16 Intention to buy a BEV

Table 5-16 shows the mean and standard deviation of responses to the three questions regarding the intention to buy a BEV. These questions are as follows:

- I am willing to consider buying or leasing a Battery Electric Car.
- I intend to buy or lease a Battery Electric Car a year from now.
- If I have the chance to buy a second car, I am willing to buy or lease a Battery Electric Car.

Regarding the intention to buy a BEV, the following information can be drawn from Figure 5-17:

- *About 43 percent of respondents are willing to consider buying or leasing a BEV.*
- *Only about 11 percent of respondents intend to buy or lease a BEV a year from now.*
- *About 36 percent of respondents are willing to buy or lease a BEV if they have the chance to buy a second car.*
- *About 22 percent of respondents are not willing to consider buying or leasing a BEV.*
- *Only about 52 percent of respondents do not intend to buy or lease a BEV a year from now.*
- *About 31 percent of respondents are not willing to buy or lease a BEV if they have the chance to buy a second car.*

Descriptive Statistics

	N	Mean	Std. Deviation
INT 1	308	4.17	1.399
INT 2	308	3.08	1.428
INT 3	308	3.93	1.496
Valid N (listwise)	308		

Table 5-16 Descriptive analysis for Intention to Buy variable

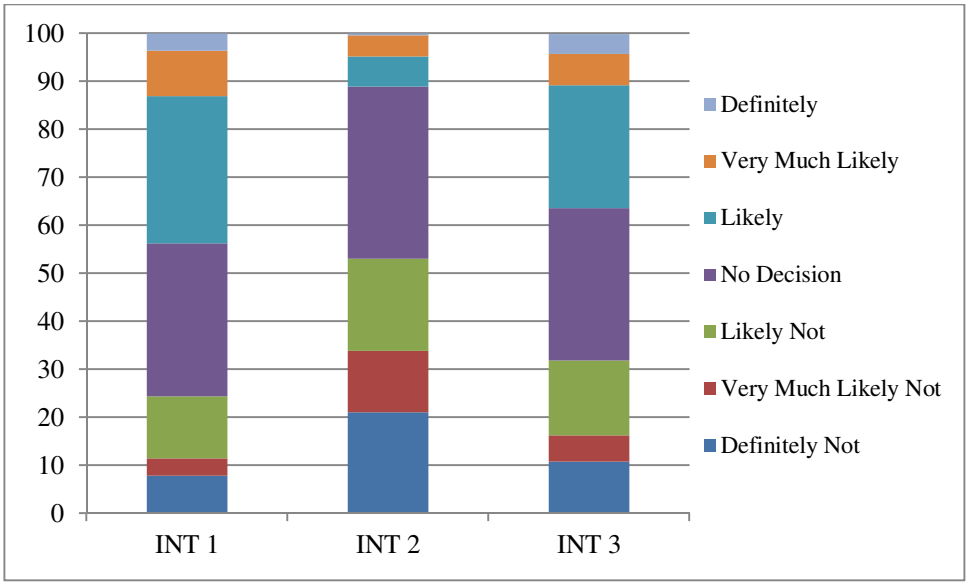

Figure 5-17 Analysis of respondents' intention to buy a BEV

5.3 Instrument final reliability test

Table 5-17 shows the final reliability test for our instrument. As it can be seen the Cronbach's Alpha and inter-item total correlations for all constructs except for Performance are greater than 0.7 and 0.3 respectively. Therefore, we use only the first item for measuring the perception of respondents about the BEV performance (PERFORMANCE 1).

Construct Name	Number of cases	Item total correlations	Cronbach's Alpha
Knowledge and Information			0.932
KW1	308	.609	-
KW2	308	.661	-
KW3	308	.575	-
KW4	308	.736	-
KW5	308	.732	-
KW6	308	.607	-
KW7	308	.774	-
KW8	308	.708	-
Perceived Risk			0.758
Risk1	308	0.522	-
Risk2	308	0.547	-
Risk3	308	0.627	-
Risk4	308	0.531	-
Financial Incentives			0.720
FIN INCENTIVE 1	308	0.456	-
FIN INCENTIVE 2NE	308	0.645	-
FIN INCENTIVE 3NE	308	0.533	-
Performance			0.282
PERFORMANCE 1	308	0.313	-
PERFORMANCE 2NE	308	0.317	-
PERFORMANCE 3 G	308	0.124	-
Difficulty of Use			0.729
DIF 1	308	0.453	-
DIF 2	308	0.593	-
DIF 3	308	0.560	-
DIF 5	308	0.387	-
DIF 6	308	0.462	-
Social Pressure			0.951
SOC PRE 1	308	0.890	-
SOC PRE 2	308	0.914	-
SOC PRE 3	308	0.891	-
Social Prestige			0.899
SOC PRES 1	308	0.849	-
SOC PRES 2	308	0.848	-
SOC PRES 3	308	0.708	-

Table 5-17 Final reliability test for instrument

Construct Name	Number of cases	Item total correlations	Cronbach's Alpha
Intention to Buy			0.885
INT 1	308	0.782	-
INT 2	308	0.721	-
INT 3	308	0.828	-
Responsibility			0.915
RESP 1	308	0.816	-
RESP 2	308	0.856	-
RESP 3	308	0.819	-
Moral Obligations			0.913
MORAL OBL 1	308	0.808	-
MORAL OBL 2	308	0.800	-
MORAL OBL 3	308	0.870	-
Attitude			0.922
	308	0.829	-
	308	0.838	-
	308	0.863	-
Price			-
Fuel cost Savings			-
Usefulness to Environment			-
Product Availability			-

Table 5-18 Continued - Final reliability test for instrument

5.4 Factor analysis

In order to check the convergent and discriminant validity of constructs and also to confirm the factors and probable factor reduction, we conducted a factor analysis using SPSS version 20. We used principal components factor analysis with varimax rotation method. We surpassed all small coefficients below than 0.4.

The aim of testing the convergent and discriminant validity is to make sure that the results of research are accurate and precise. Convergent and discriminant validity are opposites. According to Salisbury et al., 2002 the convergent validity

refers to the extent to which the items measuring one construct appear to be indicators of that single underlying construct. On the other hand, the discriminant validity means that items measuring one factor can be differentiated from the items measuring the other factors (Bagozzi & Phillips, 1982). One of the popular methods to test the convergent and discriminant validity of an instrument is to use exploratory factor analysis (Tojib & Sugianto, 2011). The EFA[7] method to test the convergent and discriminant includes the assessment of eigenvalues of 1, item loadings of at least 0.4 and no cross- loading of items above 0.4 (Tojib & Sugianto, 2011).

Table 5-19 shows the results if factor analysis. A principal components analysis (PCA) was conducted on the 30 items with orthogonal rotation (varimax). The Kaiser-Mayer-Olkin measure verified the sampling adequacy for the analysis, KMO= 0.83 ("great" according to Kaiser, 1974) and all KMO values for individual items were > 0.66, which is well above the acceptable limit of 0.5 (Field, 2009) Bartlett's test of sphericity $\chi 2 = 5066$, $p < 0.001$, indicate that the correlations between items were significantly large for PCA. An initial analysis was run to obtain eigenvalues for each component in the data. Seven components had the eigenvalues over the Kaiser's criterion of 1 and in combinations explained 67% of the variance.

Table 5-19 shows the factor loadings after rotations. The items that cluster on the same components suggest that component 1 represents the knowledge and information, component 2 represents the combination of social prestige, fuel cost savings and environment usefulness factors that we can name this component the overall relative advantage, component 3 represents social pressure, component 4 represents difficulty of use but it only consists of 3 items of original difficulty of use factor in our model including long charging time (DIF 1), driving range

[7] EFA: Exploratory Factor Analysis

problem (DIF 2), and routines (DIF 3), component 5 represents financial incentives and price, component 6 represents perceived risk, and finally component 7 represents the new factor that we can name it the lack of infrastructure and product and it consists of the other 2 items of original difficulty of use factor including lack of charging stations and difficulty of find an auto repair shop and the product availability variable. The performance variable did not load on any component because it had the load factor less than cutoff point (0.4)

As it can be seen in the table 5-19, two variables including KW3 and Risk 4 have the high cross loadings on two factors. Therefore, we deleted these two factors from our data analysis in order to meet the convergent and discriminant validity requirements. Table 5-20 shows our revised factor analysis including the extracted components and factor loadings on each component.

The results of the factor analysis as it is shown in table 5-20 confirm the convergent and discriminant validity of our constructs as the loading factor of each item on the related component is at least 0.4 and there are no cross loadings of items more than 0.4.

Regarding the necessary sample size for factor analysis, the common rule is to have at least 10-15 participants per variable. In this research we have 11 variables so our sample size (308) seems to be enough. According to Tabachnick and Fidell (2007) the sample size about 300 cases for factor analysis is comforting. As it can be seen in the table 5-21 as an alternative way, we used the KMO measure of sampling adequacy (Kaiser, 1970) for our research. According to Kaiser (1974) the KMO value between 0.8 and 0.9 is great for factor analysis.

Rotated Component Matrix[a]

	Component							
	1	2	3	4	5	6	7	8
KW7 PERFORMANCE	.899							
KW4 MODELS AND BRANDS	.876							
KW5 PRICE RANGE	.865							
KW8 CHARGING	.846							
KW2 HOW-WORKS	.796							
KW6 FIN-INCEN	.775							
KW3 COST-SAVINGS	.720							.427
KW1 ENV-BEN	.698							
SOC PRE 2		.900						
SOC PRE 3		.897						
SOC PRE 1		.894						
SOC PRES 2			.908					
SOC PRES 1			.908					
SOC PRES 3			.776					
DIF 1 LONG CHARGING TIME				.810				
DIF 2 RANGE				.750				
DIF3 ROUTINES				.707				
RISK 4 CHARGING				.521	.483			
RISK 1 MAINTENANCE					.794			
RISK 2 SELLING					.707			
RISK 3 FAILURE				.405	.682			
PERFORMANCE 1								
FIN INCENTIVE 2NE						.787		
FIN INCENTIVE 3NE						.748		
FIN INCENTIVE 1						.722		
PRICE						-.433		
DIF 5 CHARGING STATIONS							.823	
DIF 6 REPAIR							.750	
MODEL 1							.427	
FCS1								.787
ENVIRONMENT								.652

Table 5-19 Factor analysis on independent variables

Rotated Component Matrix[a]

	Component						
	1	2	3	4	5	6	7
KW7 PERFORMANCE	.902						
KW4 MODELS AND BRANDS	.877						
KW5 PRICE RANGE	.871						
KW8 CHARGING	.853						
KW2 HOW-WORKS	.791						
KW6 FIN-INCEN	.787						
KW1 ENV-BEN	.687						
SOC PRES 1		.865					
SOC PRES 2		.846					
SOC PRES 3		.807					
ENVIRONMENT		.539					
FCS1		.428					
SOC PRE 3			.892				
SOC PRE 2			.891				
SOC PRE 1			.885				
DIF 1 LONG CHARGING TIME				.801			
DIF 2 RANGE				.751			
DIF3 ROUTINES				.709			
FIN INCENTIVE 2NE					.798		
FIN INCENTIVE 3NE					.730		
FIN INCENTIVE 1					.724		
PRICE					-.447		
RISK 1 MAINTENANCE						.796	
RISK 2 SELLING						.720	
RISK 3 FAILURE						.670	
PERFORMANCE 1							
DIF 5 CHARGING STATIONS							.747
DIF 6 REPAIR							.664
MODEL 1							.563

Table 5-20 Revised factor analysis on independent variables

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.829
Bartlett's Test of Sphericity	Approx. Chi-Square	5066.224
	df	406
	Sig.	.000

Table 5-21 Measure of sample adequacy for factor analysis

5.5 Multiple regression analysis

In this section, we explain the results of multiple regression analysis. We conducted a regression analysis in order to test our hypotheses that we have developed in chapter 3. The multiple regression analysis is a method of predicting the outcome or dependent variable from several predictor or independent variables. It helps us to find not only the significance of the relationships between independent and dependent variables but also the relative importance of independent variables which is the main goal of this research. The method of regression that we used is forced entry. The forced entry method is an appropriate method when there is a good theoretical framework to include all predictor variables in the research model but the researcher makes no prior decision about the orders in which variables are entered. In order to make sure that our research results are generalizable and reliable, we checked the requirements of multiple regression method such as no perfect multicollinearity and normal distribution of errors. All requirements were met. We also cross checked our research model with structural equation modeling softwares such as AMOS and SMART PLS in order to make sure that the research results are reliable.

In total, we tested four models. Table 5-22 shows the differences among our models in terms of dependent and independent variables. The first model is our

original research model that includes the intention to buy a BEV as a dependent variable and the all 11 factors that we explained them in chapter 3 as the independent variables. In the second model, we substituted the relative advantage with the social prestige, fuel cost savings, and usefulness for environment variables to check whether our model improves in terms of explained variance or not. In the third model, we substituted the attitude with the eight factors that we believe they are the determinants of attitude toward using a BEV including perceived risk, difficulty of use, social prestige, performance, fuel cost savings, usefulness for environment, knowledge and information, and financial incentives and then tested the model, placing the intention to buy a BEV as a dependent variable and attitude toward using a BEV, price, product availability, and social pressure as the independent variables. In the last model, we placed the attitude toward using a BEV as dependent variables and perceived risk, difficulty of use, social prestige, performance, fuel cost savings, usefulness for environment, knowledge and information, and financial incentives as the independent variables to test the significance level of each relationship and the relative importance of these factors on consumers' attitude.

Tables 5-23 and 5-24 show the regression model summary for our first model and the significance level and regression coefficient for each factor. As it can be seen, seven variables including the difficulty of use, price, perceived risk, social pressure, social prestige, usefulness for environment, and knowledge and information have the significance level less than 0.05 and the other variables including fuel cost savings, financial incentives, product availability, and performance are not significant. According to table 5-23, 48.7% of variation in intention to buy a BEV is explained by these factors. Durbin-Watson test is 1.869 that is acceptable. The VIF for all variables is close to 1 that confirms that Collinearity is not a problem for our model.

Model	Dependent Variable	Independent Variables
First Model	Intention to buy	Social pressure, perceived risk, difficulty of use, social prestige, performance, fuel cost savings, usefulness for environment, knowledge and information, financial incentives, product availability, price
Second Model	Intention to buy	Social pressure, perceived risk, difficulty of use, performance, relative advantage, knowledge and information, financial incentives, product availability, price
Third Model	Intention to buy	Attitude, social pressure, price, product availability
Fourth Model	Attitude	Perceived risk, difficulty of use, social prestige, performance, fuel cost savings, usefulness for environment, knowledge and information, financial incentives

Table 5-22 – The summary of models used in regression analysis

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.698[a]	.487	.468	.94933	.487	25.491	11	295	.000	1.869

a. Predictors: (Constant), FCS1, KW, FINANCIAL, PERFORMANCE 1, MODEL 1, PRICE, SOC_PRESTIGE, RISK, ENVIRONMENT, SOC_PRE, DIFFICULTY1

b. Dependent Variable: INTENTION_ADOPT

Table 5-23 Regression model summary for the original model

Coefficients[a]

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Correlations			Collinearity Statistics	
	B	Std. Error	Beta			Zero-order	Partial	Part	Tolerance	VIF
(Constant)	2.827	.708		3.996	.000					
PRICE	-.135	.047	-.127	-2.877	.004	-.252	-.165	-.120	.885	1.129
RISK	-.148	.062	-.119	-2.387	.018	-.328	-.138	-.100	.701	1.427
DIFFICULTY1	-.247	.080	-.162	-3.099	.002	-.256	-.178	-.129	.636	1.572
SOC_PRE	.326	.052	.316	6.251	.000	.527	.342	.261	.678	1.475
SOC_PRESTIGE	.177	.045	.200	3.911	.000	.506	.222	.163	.662	1.511
KW	.089	.042	.094	2.096	.037	.247	.121	.087	.866	1.155
FINANCIAL	-.024	.065	-.017	-.363	.717	.196	-.021	-.015	.790	1.266
PERFORMANCE 1	.021	.045	.022	.463	.644	.317	.027	.019	.778	1.285
ENVIRONMENT	.198	.053	.185	3.755	.000	.401	.214	.157	.716	1.396
MODEL 1	.098	.058	.080	1.679	.094	-.002	.097	.070	.757	1.322
FCS1	.031	.057	.026	.552	.581	.234	.032	.023	.814	1.228

a. Dependent Variable: INTENTION_ADOPT

Table 5-24 Regression coefficients for the original model

Tables 5-25 and 5-26 show the regression model summary for our second model and the significance level and regression coefficient for each factor. In the second model, we substituted the relative advantage with the social prestige, fuel cost savings, and usefulness for environment variables to check whether our model improves in terms of explained variance or not. As it can be seen, our second model has not improved in terms of explained variance as according to table 5-25, 47.8% of variation in intention to buy a BEV is explained by the second model compared to 48.7% explained by the first model. Six variables including the difficulty of use, price, perceived risk, social pressure, knowledge and information, and relative advantage have the significance level less than 0.05 and the other variables including financial incentives, product availability, and performance are not significant. Durbin-Watson test is 1.85 that is acceptable. The VIF for all

variables is close to 1 that confirms that Collinearity is not a problem for our model.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.691[a]	.478	.462	.95511	.478	30.163	9	297	.000	1.854

a. Predictors: (Constant), Relative_Advantage, MODEL 1, KW, PRICE, FINANCIAL, PERFORMANCE 1, RISK, SOC_PRE, DIFFICULTY1

b. Dependent Variable: INTENTION_ADOPT

Table 5-25 Regression model summary for the second model

Coefficients[a]

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Correlations			Collinearity Statistics	
	B	Std. Error	Beta			Zero-order	Partial	Part	Tolerance	VIF
(Constant)	2.985	.672		4.442	.000					
PRICE	-.145	.047	-.137	-3.075	.002	-.252	-.176	-.129	.893	1.120
RISK	-.156	.062	-.125	-2.494	.013	-.328	-.143	-.105	.704	1.420
DIFFICULTY1	-.225	.079	-.147	-2.831	.005	-.256	-.162	-.119	.648	1.543
SOC_PRE	.317	.052	.308	6.140	.000	.527	.336	.258	.699	1.431
KW	.092	.042	.098	2.177	.030	.247	.125	.091	.868	1.152
FINANCIAL	-.018	.066	-.013	-.270	.788	.196	-.016	-.011	.792	1.263
PERFORMANCE 1	.022	.045	.024	.496	.620	.317	.029	.021	.779	1.284
MODEL 1	.108	.058	.089	1.873	.062	-.002	.108	.079	.776	1.289
Relative_Advantage	.380	.058	.318	6.504	.000	.545	.353	.273	.736	1.358

a. Dependent Variable: INTENTION_ADOPT

Table 5-26 Regression coefficients for the second model

Tables 5-27 and 5-28 show the regression model summary for our third model and the significance level and regression coefficient for each factor. In the third model, we substituted the attitude with the eight factors that we believe they are the determinants of attitude including perceived risk, difficulty of use, social prestige, performance, fuel cost savings, usefulness for environment, knowledge and information, and financial incentives and then tested the model, placing the intention to buy a BEV as a dependent variable and attitude toward using a BEV, price, product availability, and social pressure as the independent variables. As it can be seen, our third model has improved in terms of explained variance as according to table 5-27, 53.2% of variation in intention to buy a BEV is explained by the third model compared to 48.7% explained by the first model. All independent variables except product availability have the significance level less than 0.05. Durbin-Watson test is 1.86 that is acceptable. The VIF for all variables is close to 1 that confirms that Collinearity is not a problem for our model.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.730[a]	.532	.526	.89462	.532	86.235	4	303	.000	1.861

a. Predictors: (Constant), MODEL 1, SOC_PRE, PRICE, ATTITUDE

b. Dependent Variable: INTENTION_ADOPT

Table 5-27 Regression model summary for the third model

Coefficients[a]

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Correlations			Collinearity Statistics	
	B	Std. Error	Beta			Zero-order	Partial	Part	Tolerance	VIF
(Constant)	1.052	.395		2.663	.008					
ATTITUDE	.554	.047	.510	11.858	.000	.647	.563	.466	.833	1.200
SOC_PRE	.311	.044	.302	7.009	.000	.527	.374	.275	.831	1.203
PRICE	-.182	.042	-.171	-4.290	.000	-.252	-.239	-.169	.970	1.031
MODEL 1	.060	.048	.049	1.250	.212	-.002	.072	.049	.985	1.015

a. Dependent Variable: INTENTION_ADOPT

Table 5-28 Regression coefficients for the third model

Tables 5-29 and 5-30 show the regression model summary for our fourth model and the significance level and regression coefficient for each factor. In the fourth model, we placed the attitude toward using a BEV as dependent variables and perceived risk, difficulty of use, social prestige, performance, fuel cost savings, usefulness for environment, knowledge and information, and financial incentives as the independent variables to test the significance level of each relationship and the relative importance of these factors on consumers' attitude. According to table 5-29, 57.2% of variation in attitude toward using a BEV is explained by these factors. All independent variables except financial incentives have the significance level less than 0.05. Durbin-Watson test is 2 which is acceptable. The VIF for all variables is close to 1 that confirms that Collinearity is not a problem for our model.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.756[a]	.572	.560	.79515	.572	49.735	8	298	.000	2.011

a. Predictors: (Constant), PERFORMANCE 1, KW, FCS1, FINANCIAL, SOC_PRESTIGE, DIFFICULTY1, ENVIRONMENT, RISK

b. Dependent Variable: ATTITUDE

Table 5-29 Regression model summary for the attitude as a dependent variable and its determinants

Coefficients[a]

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Correlations			Collinearity Statistics	
	B	Std. Error	Beta			Zero-order	Partial	Part	Tolerance	VIF
(Constant)	2.597	.539		4.816	.000					
SOC_PRESTIGE	.350	.035	.429	9.898	.000	.636	.497	.375	.764	1.308
DIFFICULTY1	-.180	.062	-.128	-2.893	.004	-.276	-.165	-.110	.735	1.361
FINANCIAL	-.029	.053	-.023	-.545	.586	.165	-.032	-.021	.844	1.185
RISK	-.172	.052	-.149	-3.312	.001	-.383	-.188	-.126	.708	1.412
KW	.095	.034	.110	2.828	.005	.220	.162	.107	.957	1.045
ENVIRONMENT	.226	.044	.229	5.166	.000	.490	.287	.196	.732	1.367
FCS1	.111	.047	.098	2.355	.019	.346	.135	.089	.832	1.202
PERFORMANCE 1	.091	.037	.104	2.460	.014	.384	.141	.093	.807	1.239

a. Dependent Variable: ATTITUDE

Table 5-30 Regression coefficients for the attitude as a dependent variable and its determinants

5.6 Research results and discussion

Table 5-31 shows the results of hypotheses testing, using the regression analysis. As it can be seen, seven factors out of eleven factors influence significantly the rate of adoption of battery electric vehicles. These variables include the social pressure, social prestige, usefulness for environment, difficulty of use, price, perceived risk, and knowledge and information. Other variables including financial incentives, product performance, fuel cost savings, and product availability do not influence the rate of adoption significantly and so our hypotheses regarding these variables are not supported by our research.

Table 5-32 shows the relative importance of factors. Whereas the social pressure to use a BEV is the most important factor, knowledge and information about BEV is the less important factor. The next important factor is social prestige which is followed by usefulness for environment. The next important factors are difficulty of use, price, and perceived risk which negatively influence the rate of BEV adoption.

It can be argued that the main reason behind the lack of support for financial incentives and product availability in our research is that the respondents have the little information about these variables. As we indicated in this chapter, about 60 to 75 percent of respondents have little information about the financial incentives offered by the government of Ontario to buy a BEV and the BEV available models and brands in the market so it is not surprising that these two variables are not significant because many respondents have not heard about these factors at all.

Regarding the fuel cost savings and BEV performance, the main question is that why these two variables do not significantly influence the intention to buy a BEV directly but as it can be seen in the previous section, their effect on respondents' attitude is significant?

Hypotheses	Supported	Not supported
H1: The higher, price of a battery electric vehicle in a market, the less, people adopt that battery electric vehicle.	✓	
H2: the more there is social pressure to adopt a battery electric vehicle in a social system, the more people adopt that battery electric vehicle.	✓	
H3: The more people perceive the use of a battery electric vehicle as difficult, the less they adopt that battery electric vehicle.	✓	
H4: the more people have the knowledge and information about a battery electric vehicle, the more they adopt that battery electric vehicle.	✓	
H5: The higher people perceive the risk of using a battery electric vehicle, the less they adopt that battery electric vehicle.	✓	
H6: The more people perceive they cannot find and buy their desired battery electric vehicle brand and model, the less they adopt that battery electric vehicle.		✓
H7: The more people perceive that battery electric vehicle is useful for the environment, the more they adopt battery electric vehicles.	✓	
H8: The more people perceive that performance of a battery electric vehicle is better than that of a similar internal combustion engine vehicle, the more they adopt that battery electric vehicle.		✓
H9: The higher people feel that using a battery electric vehicle is a prestigious behavior, the more they adopt that battery electric vehicle.	✓	
H10: The higher people perceive the fuel cost savings of using a battery electric car is considerable, the more they adopt that battery electric vehicle.		✓
H11: The higher people perceive the financial incentives offered by change agents to buy a battery electric vehicle are attractive, the more they adopt that battery electric vehicle.		✓

Table 5-31 Results of hypotheses testing

In other words, it seems that these variables influence the rate of BEV adoption indirectly and through a mediator variable which in this context is attitude. The answer to this question is not easy. We can argue that the these two variables affect the respondents' attitude to the some extent but the effect is not so strong that can reflect on respondents' intention to buy a BEV. In order to have a better understanding in this matter, we need to explain why we entered the attitude into our third model and substituted it with eight factors including perceived risk, difficulty of use, social prestige, performance, fuel cost savings, usefulness for environment, knowledge and information, and financial incentives. In addition, we need to explain why we did not substitute attitude with price and product availability in the third model. For answering these questions, we need to review the Rogers' theory of diffusion of innovation and also explain to some extend the theory of planned behavior proposed by Ajzen in 1985.

Variable	The Relative Importance	The Overall Ranking
Positive effect on the rate of adoption		
Social Pressure	1	1
Social Prestige	2	2
Usefulness for environment	3	3
Knowledge and information	4	7
Negative effect on the rate of adoption		
Difficulty of use	1	4
Price	2	5
Perceived risk	3	6

Table 5-32 - The relative importance of variables on the rate of BEV adoption

As we explained in chapter 3, According to Rogers (1962), the first step in the diffusion process starts when an individual or other unit of adoption gains the information about the existence of an innovation and how it functions. Based on this knowledge and information, an individual forms a favorable or unfavorable attitude toward the innovation and persuaded or not persuaded to adopt the innovation. The attributes of the innovation and how an individual perceives those attributes play important roles in this step. In the next step, an individual makes a decision to adopt or reject the innovation. Therefore, we can conclude that attitude plays a mediating role in the diffusion process and based on what people perceive from the attributes of an innovation such as performance, fuel cost savings, difficulty of use, perceived risk and other attributes, an individual forms attitude toward adopting or rejecting that innovation. This explains why we substituted attitude with eight factors including perceived risk, difficulty of use, social prestige, performance, fuel cost savings, usefulness for environment, knowledge and information, and financial incentives. All these factors affect the attitude of an individual and then based on the extent to which this attitude is favorable or unfavorable, an individual makes a decision to adopt or reject an innovation. Perhaps this question comes to our mind that if the attitude plays such an important role in the diffusion process, why Rogers did not put this variable into his model. One probable answer is that Rogers is a socialist and looks at the diffusion process from the social point of view not from psychology point of view which deals with attitude and beliefs.

In order to answer the second question – why we did not substitute the attitude with price and product availability in the third model- we need to explain the theory of planned behavior proposed by Ajzen in 1985. The theory of planned behavior proposed by Ajzen (1985) is the extension of the theory of reasoned action and it deals with range of behaviors which cannot be predicted by the theory

of reasoned action. The theory of planned behavior tries to explain why an individual fails to perform a social behavior even he has the positive attitude toward performing a behavior and important others around him approve his behavior. According to this theory successful performance of social behavior depends on "the degree of control a person has over internal and external factors that may interfere with the execution of an intended action" (Ajzen, 1985). In order to understand the theory of planned behavior we should first review the main concepts of theory of reasoned action.

The theory of reasoned action, proposed by Ajzen and Fishbein in 1975, deals with behaviors which people can easily perform them if they intend to do so. Two main assumptions in this theory are: (1) people behave in a sensible manner and (2) the individual's behaviors are under volitional control i.e. people can easily perform the behavior if they intend to do so. According to Ajzen (1985), the intention to perform a behavior is the immediate determinant of that behavior. Two determinants of intention are attitude toward the behavior and subjective norms. Attitude toward a behavior is the final positive or negative evaluation about performing that behavior. In other words, we have some beliefs about the consequences of performing a specific behavior and based on these beliefs we form a positive or negative attitude toward performing that behavior. It is important to know that here we talk about attitude toward performing a behavior and not about general attitude toward an object. According to Ajzen (1985) subjective norm is "the person's perception of the social pressure put on him to perform or not perform the behavior in question". Therefore, if a person has a positive attitude toward performing a behavior and important others approve his behavior, he intends to perform that behavior.

Figure 5-18 shows the schematic model for theory of planned behavior. As we see the perceived behavioral control was added to the theory of reasoned

action. The perceived behavioral control is "people's perception of the ease or difficulty of performing the behavior of interest" (Ajzen, 1985). Generally speaking, a person intends to perform a behavior when he has the positive attitude toward performing that behavior, important others approve his behavior and put pressure on him to do it, and he perceives that he has the required skill, ability, resources, and opportunity to do such behavior. Therefore, theory of planned behavior expands the theory of reasoned action and permits it to deal with some kinds of behaviors which require skills, ability, and opportunity to perform them and so people usually plan to do such behaviors in advance.

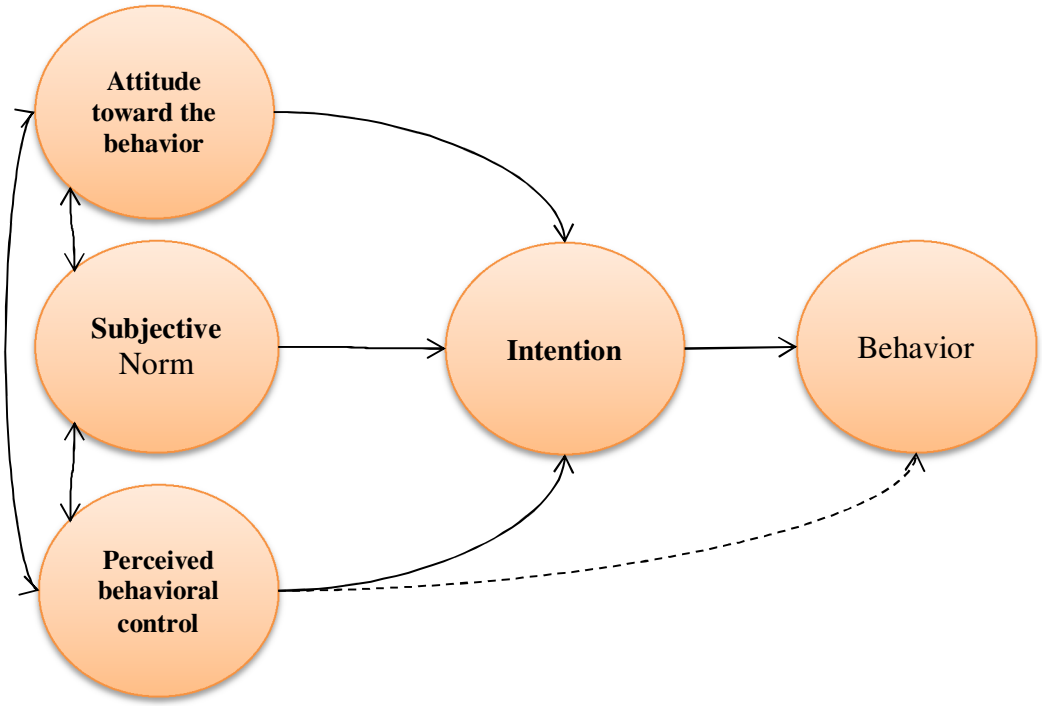

Figure 5-18 Theory of planned behavior (source: Ajzen, 1985)

The above explanation answers our second question clearly. Aligned with what Ajzen proposed in the theory of planned behavior, the main reason we did not substitute the attitude with price and product availability in our third model is that these two variables in our context are exactly the same as what Ajzen defined as

the perceived behavioral control variable. In other words, in our context, price and product availability play a role of control for the adoption behavior rather than contribute to forming an attitude.

To make it short, we can conclude that an individual can form a positive or negative attitude toward using a BEV based on a typical BEV attributes such as perceived risk, difficulty of use, social prestige, performance, fuel cost savings, usefulness for environment, and knowledge and information and then based on the BEV price and availability of his or her desired brands and models in the market, he or she makes a final decision to buy or not to buy a BEV. Of course, both diffusion of innovation theory and theory of planned behavior indicate that another variable affects an individual decision to adopt or reject an innovation other than attitude and perceived behavioral control and it is the social pressure. That is why it is not surprising that the social pressure is the most important factor in our research model because both theories indicate that the social pressure is one of the most important determinants of actual behavior.

The above discussion leads us to revise our first model based on the fact that using attitude as a mediator variable improved our first model in terms of explained variance as according to table 5-27, 53.2% of variation in intention to buy a BEV is explained by the third model compared to 48.7% explained by the first model. Figure 5-19 shows our revised model for the diffusion of BEVs in urban areas.

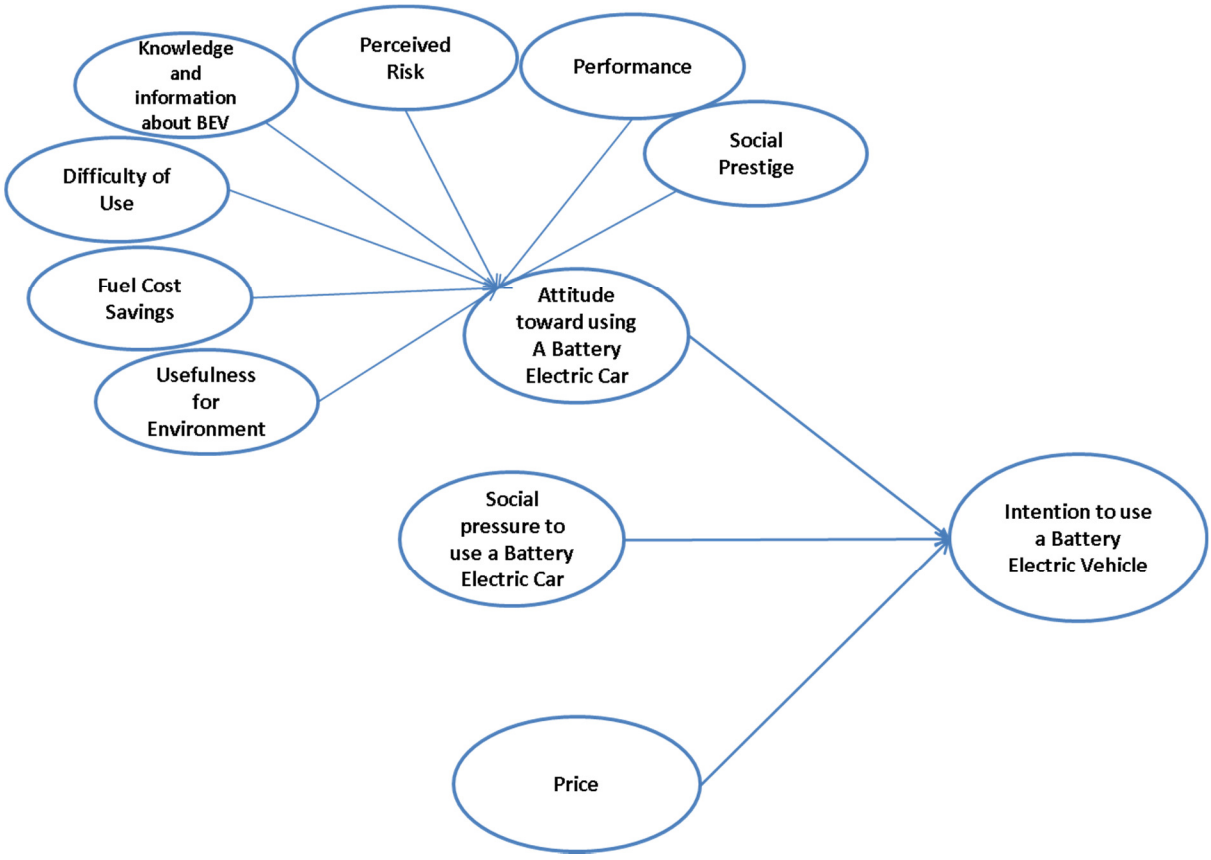

Figure 5-19 Revised model for diffusion of battery electric vehicles

6
Proposed Roadmap and policies for Diffusion of BEVs in Urban Areas

As we explained in the previous chapter, social prestige, usefulness for environment, perceived risk, difficulty of use, knowledge and information, performance, and fuel cost savings indirectly and through the attitude and social pressure and price directly influence the intention to buy a BEV. Clearly, all policies to accelerate the diffusion of battery electric vehicles should be addressed these factors. In this chapter, we propose a roadmap for diffusion of BEVs in urban areas and also propose a set of policies for increasing the rate of adoption of BEVs in urban areas.

The most important point regarding the proposed roadmap and policies in this chapter is that the diffusion of BEVs would be successful if the proposed roadmap and all policies are implemented under one integrated program. Obviously, implementing each solution individually without considering the effect of other policies or implementing only part of the proposed policies would not be effective and it does not lead to a successful diffusion of BEVs in urban areas.

6.1 Proposed roadmap for the diffusion of BEVs

Figure 6-1 shows our proposed roadmap for diffusion of battery electric vehicles in urban areas. Figure 6-2 depicts the logic behind how this roadmap works.

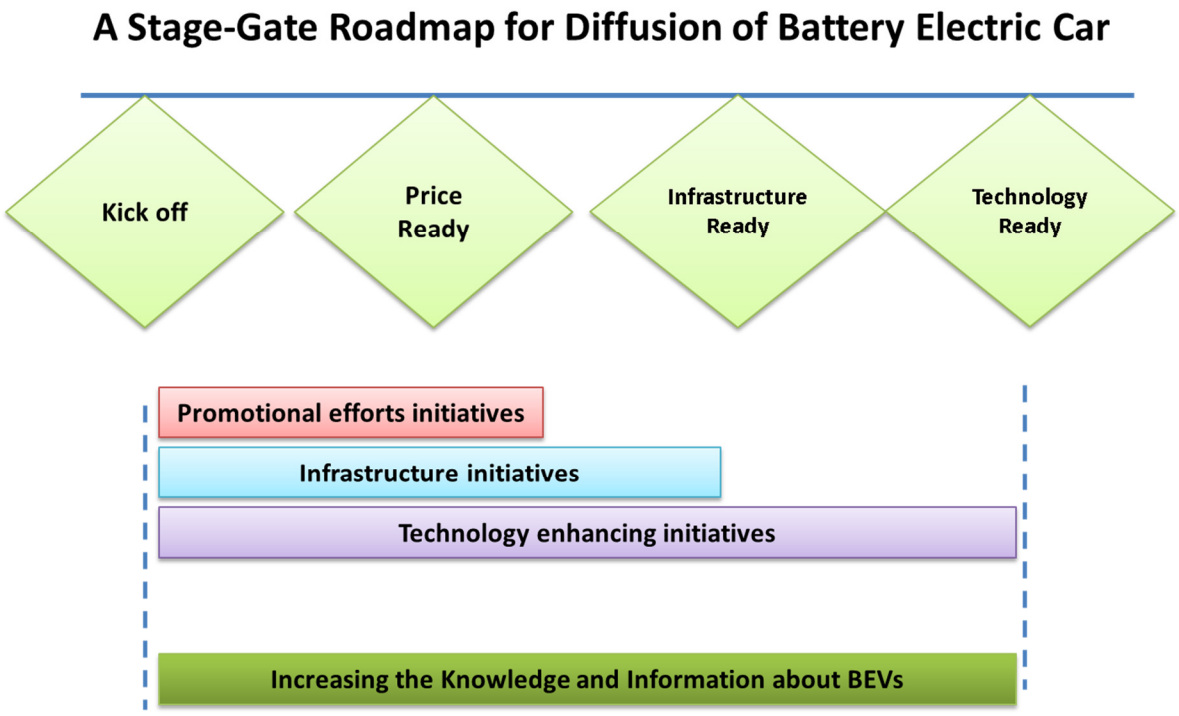

Figure 6-1 A proposed roadmap for diffusion of battery electric vehicles

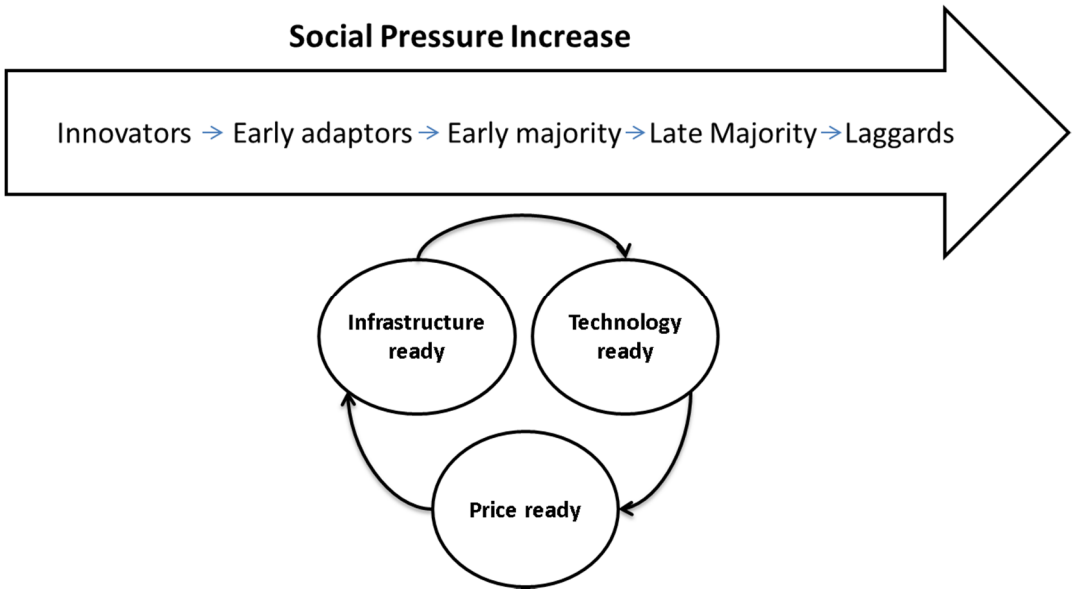

Figure 6-2 –The logic of diffusing the battery electric vehicles in urban areas

As the results of our research shows the most important factor to diffuse battery electric vehicles in urban areas is the social pressure to use a BEV but the main question is that how can we increase the social pressure in a society? The social pressure does not increase unless a source of pressure exists in a social system. Therefore, this question comes to our mind that who can be a source of pressure in a society? This source of pressure should be the people who are less concerned about price, seeking for more information, having a wide interpersonal network, more access to mass media, and they have more patience to deal with high risks and difficulty of use of BEVs such as long charging time, short range, and lack of enough charging stations. As we explained in chapter 2, this profile of people belongs to innovators. These people can gradually put pressure to other people in a society in a way that they feel they should adopt a BEV. Therefore, we need to identify, target, and attract BEV innovators at the first step. Clearly, the first set of policies to attract innovators should address the promotional efforts

specifically the financial incentives because the price should be affordable for such people.

In line with providing price based policies for innovators, we need to start investing and developing the required infrastructure for the next group of people who are more concerned about the risks and difficulty of use of BEVs. These group of people based on Rogers (1983) definition are called the early adaptors. This group of people needs more ease of use and financial policies and should perceive less risk to use a BEV. Gradually innovators and early adaptors put more social pressure to other people in a society including early majority and late majority and incline them to adopt and use BEVs. At the same time BEV manufacturers can provide more reliable and easy to use products in a market because by this time the product technology specifically battery technology will be more matured and sophisticated.

Parallel with all these actions, the knowledge and information about BEVs should increase in a society. Change agents should initiate some creative solutions in order to increase the knowledge and information about the various aspects of BEVs such as the benefits of using BEVs and the consequences of using ICEVs on environment.

As it can be seen, our proposed roadmap addresses the main factors that influence the rate of adoption of BEVs such as social pressure, difficulty of use, risks, price, knowledge and information, product performance. At this point we need a set of initiatives that enable change agents such as municipalities to diffuse BEVs in the market based on the above mentioned factors.

6.2 Proposed policies for diffusion of battery electric vehicles in urban areas

As we explained earlier, providing the price based policies is critical for diffusion of BEVs because we need to have a momentum in a society in order to get BEVs diffused. Unfortunately, the price of current BEV models and brands in the market are so higher than that of a similar internal combustion engine vehicle. Figure 6-3 shows the price difference between some BEV models and their ICEV counterparts in the market. As can be seen, the price of a BEV model is almost double that of a similar ICEV model in the market. Two main reasons account for this price difference: (1) The price of a battery and (2) the economy of scale of BEV productions.

Figure 6-4 shows the lithium-ion battery price per kWh forecast from 2012-2020. As shown in figure 6-4 the lithium-ion battery price per kWh decreases dramatically during the next 8 years and it would be around $250 per kWh in 2020 which considerably affects the price of battery electric vehicle at that time. In fact, almost all electric car manufacturers use lithium-based batteries for their productions. The energy and power density of lithium-ion batteries is much more than the NiMH batteries and lead acid batteries. According to Chiang (2006) lithium-ion batteries are capable to reach specific energies as high as 300 Wh/kg on a cell basis. In addition, lithium-ion batteries are less expensive than NiMH batteries and have the potential to be cheaper as the technology advances and production volumes increase. Although the lithium-ion batteries have some problems such as safety, calendar life and life cycle, the future of these batteries are quite promising as the technology improves and matures.

Table 6-1 shows our calculation for the contribution of economy of scale on the price of three cars in the market. This calculation is based on the current price

of three conventional cars and their similar battery electric models in the market and also the cost of main parts and components of conventional and battery electric cars.

Figure 6-5 shows the contribution of battery cost, economy of scale, and other parts on the price difference of a typical BEV and ICEV. As can be seen, the cost of battery accounts for the 70% of price difference between a typical ICEV and its similar BEV.

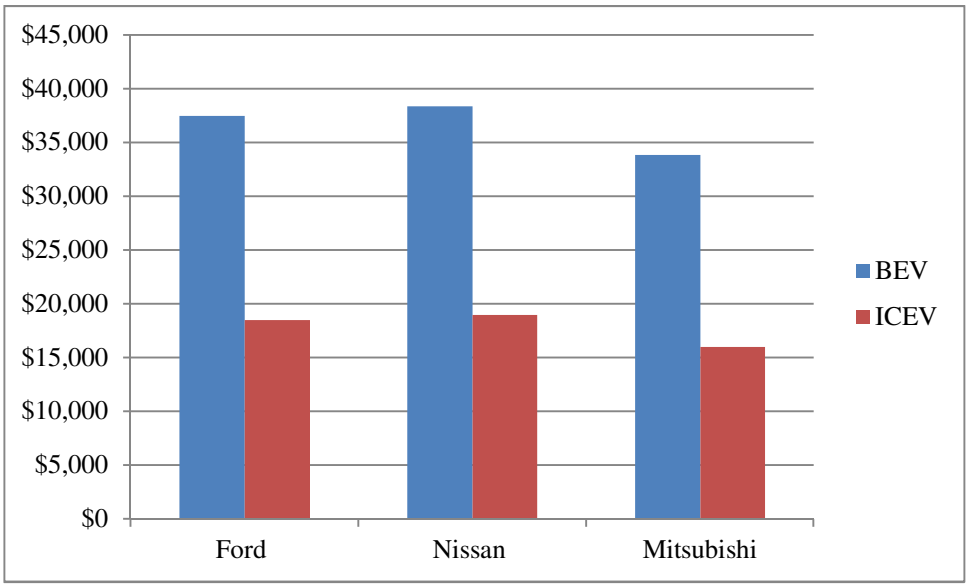

Figure 6-3 - The price difference between BEV and ICEV version of three car manufacturers: Ford Focus gasoline and BEV version, Nissan Versa 1.8SL Hatchback and Nissan Leaf, Mitsubishi Lancer Sedan and Mitsubishi i

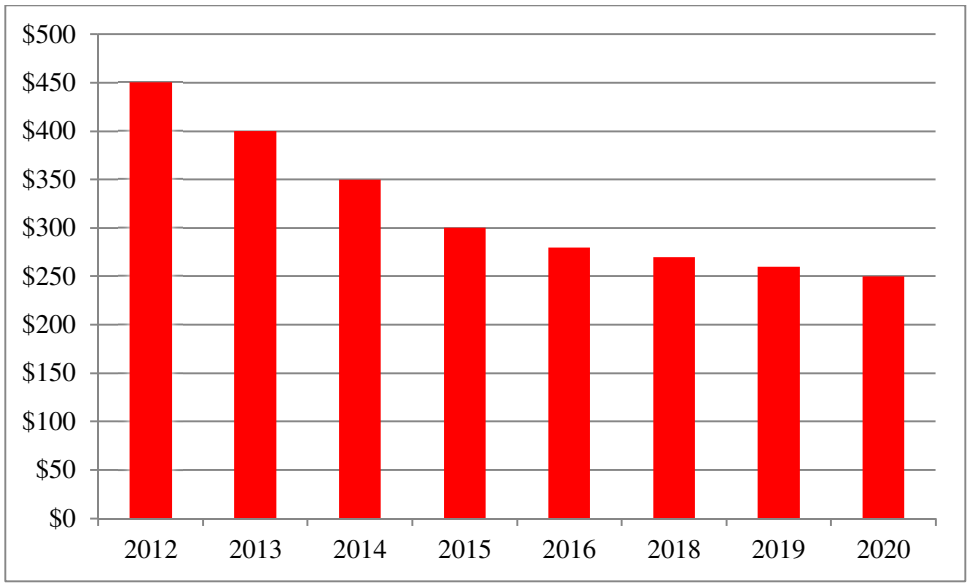

Figure 6-4 Lithium-ion battery price forecast per kWh (Deutsche bank report, 2010)

	Ford	Nissan	Mitsubishi
ICEV model price	$18520	$18987	$19998
Engine and Transmission	($3000)	($3000)	($3000)
Exhaust system	($300)	($300)	($300)
Battery	$15600	$15600	$10400
Motor/Controller	1400	1400	950
One speed transmission	$200	$200	$200
Wiring	$200	$200	$200
Charger	$400	$400	$400
BEV model price without considering economy of scale	$33020	$33487	$28848
Current BEV MSRP price (2011)	$37477	$38395	$33891
Economy of scale contribution	$4457	$4908	$5043

Table 6-1 – The contribution of economy of scale on price of a typical BEV – Data is based on Kromer and John B. Heywood report, May 2007

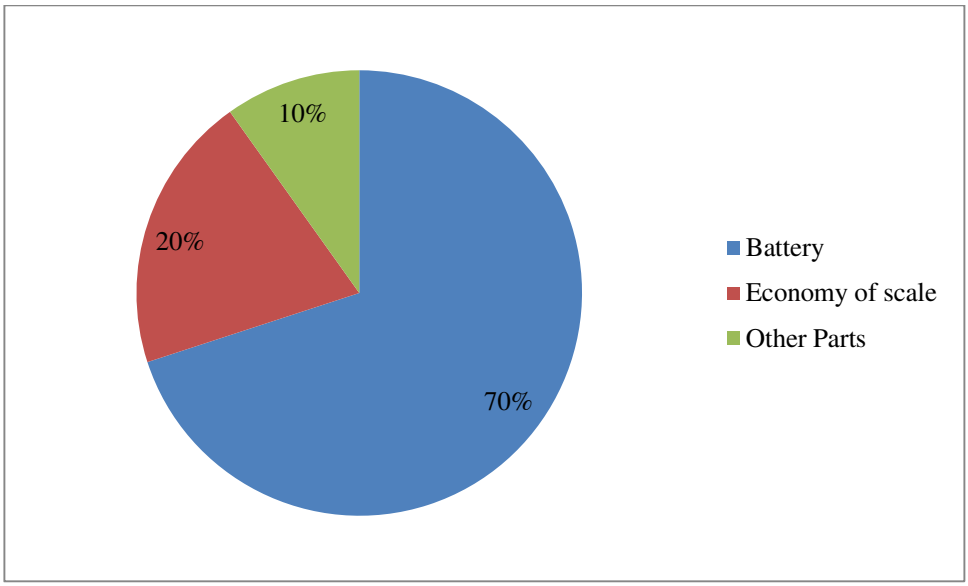

Figure 6-5- the contribution of battery cost, economy of scale and other parts on the price difference of a typical BEV and ICEV

Table 6-2 shows the price difference between a typical ICEV and its similar BEV up to 2020 with and without government subsidy. The amount of subsidy for buying a BEV in Ontario is now up to $8500 and we assume that this amount decreases over the next 8 years as shown in table 6-2. As can be seen, if we consider the total cost of ownership in 4 years, from 2015 onward the total cost of ownership for a typical BEV with government subsidy will be lower than the total cost of ownership for a typical ICEV. This table shows the importance of governmental subsidy to motivate the adoption of BEVs. It also shows that if the government considers the total cost of ownership for buying a BEV and spreads the payment of subsidy over the 4 years instead of one year, it probably can pay more subsidies per vehicle.

Regarding the price based policies to accelerate the rate of adoption of BEVs the following policies are recommended:

- Pay subsidies and financial incentives to consumers based on 4 years total cost of ownership
- Provide grants/loans or tax credits for manufacturers
- Increase environmental, fuel or congestion charges or taxes on ICEVs
- Pay the financial incentives to dealers to motivate them to sell more BEVs
- Offer more social benefits such as priority in parking lots in downtown, special lane, and free parking spaces
- Reduce or eliminate subsides for existing ICEV purchases

The other important factor that we need to address immediately is increasing the knowledge and information about BEV. As the results of our research shows the lack of knowledge and information about BEVs is one of the significant barriers to widespread use of such vehicles. The following policies are recommended to increase the knowledge and information about BEVs:

- Create a central hub for EV information. This central hub is responsible for disseminating knowledge and information regarding BEV technology, products and benefits
- Launch and fund training programs in schools, college and universities
- Funding of workforce training programs
- Funding the mass media advertisements for BEV related products and news
- Funding the free trail-days program in automotive dealers. Dealers can propose to customer up to one week free trail days in order to increase the knowledge and information about BEV performance.
- Funding the low cost BEV rent days in rental car companies. Support rental companies to offer low cost BEV rent like the weekend special offers that they have for conventional cars

	BEV Price difference 2011		BEV Price difference 2015		BEV Price difference 2020	
	With subsidy	No subsidy	With subsidy	No subsidy	With subsidy	No subsidy
ICEV base price	X	X	X	X	X	X
Engine and Transmission	(3000)	(3000)	(3300)	(3300)	(3700)	(3700)
Exhaust system	(300)	(300)	(300)	(300)	(300)	(300)
Battery	16250	16250	7500	7500	6250	6250
Motor/Controller	1400	1400	1400	1400	1400	1400
One speed transmission	200	200	200	200	200	200
Wiring	200	200	200	200	200	200
Charger	400	400	400	400	400	400
Fuel cost savings	(1920)	(1920)	(2100)	(2100)	(2160)	(2160)
Annual electric costs	400	400	360	360	334	334
Economy of scale	4500	4500	2500	2500	-	-
Government Subsidy	(8500)	-	(4500)	-	(2500)	-
Total difference in 1 year	9630	18310	2660	7160	824	3324
Total difference in 4 years	5070	13570	(2560)	1940	(4654)	(2154)
Assumptions						
Average km per year	20000	20000	20000	20000	20000	20000
Gasoline price per liter[8]	1.2	1.2	1.5	1.5	1.8	1.8
ICEV fuel consumption[9] per 100 km	8	8	7	7	6	6
Cost of electricity[10]	0.08	0.08	0.09	0.09	0.1	0.1
BEV km per kWh[11]	4	4	5	5	6	6
Battery kWh	25	25	25	25	25	25
Battery price[12]	650	650	300	300	250	250

Table 6-2- The price difference between a typical ICEV and its similar BEV, with and without government subsidy (all prices in $US)

According to our research results, social pressure to use a BEV is the most important factor in the diffusion of BEVs. Therefore, in order to get benefit of such factor we need to create and implement some specific policies. The following proposed policies are recommended to increase the social pressure to use a BEV:

[8] Gasoline price forecast by Deutsche Bank report, 2010
[9] ICEV fuel consumption based on Kromer and John B. Heywood report, May 2007
[10] Cost of electricity per kWh based on Ontario balanced rate in 2012 at http://www.ontario-hydro.com/index.php?page=current_rates
[11] BEV km per kWh based on Kromer and John B. Heywood report, May 2007
[12] Battery price based on Deutsche Bank report, 2010

- Funding and launching various campaigns in order to increase the social pressure to use BEVs. This is one of the key responsibilities of change agents such as municipalities to design and implement the effective campaigns.
- Create reference groups such as communities, cities and etc. For example , introducing green city in Ontario Province annually
- Mandated purchase of and an increasing percentage of EVs in government fleets
- Launching specific programs for increasing the moral obligations to use BEVs in urban areas

Developing the required infrastructure for charging BEVs is one of the most important actions that decrease the difficulty of use and perceived risk of using BEVs. The following policies are recommended to accelerate the development of BEV infrastructure:

- Charging stations network design in order to optimize the cost of developing infrastructure
- Initiate, encourage and fund charging station and infrastructure demonstration programs including battery swapping
- Creation of streamlined network connection agreements for electric vehicle supply equipment
- Tax reductions or exemptions for EV and charging station purchases
- Support creative investment solutions on BEV infrastructure like pay per mile solutions. Private companies should be encouraged to invest in BEV infrastructure. For example, pay per mile solution is one of the best solutions that can be implemented by private companies in Ontario. These

solutions not only reduce the load of direct investment by governments but also accelerate the development of BEV infrastructure in the shortest time.

As our research results showed the difficulty of use and perceived risk are two important factors that impede the widespread use of BEVs in urban areas. Technology of batteries and charging stations are the root cause of these factors. Improving the technology of batteries and charging stations needs investment by not only the manufacturers but also change agents. The following policies are recommended to enhance and improve the technology of BEVs:

- Establish Canadian center of excellence for research and development of lower cost, longer lifetime batteries and vehicles
- Supporting battery R&D companies

Car manufacturers and suppliers should play the key role in diffusion of battery electric vehicles. Undoubtedly, without the involvement and support of car manufacturers the diffusion of BEVs is impossible. As the results of our research shows the social prestige, BEV performance, and usefulness for environment have the significant effect on the rate of adoption so car manufacturers should address such factors in their products. Regarding the usefulness for environment factor, it is important that the whole supply chain from parts to final product manufacturers including the battery production process should be designed and operated to meet the CO2 emission. In addition, as we push for diffusion of BEVs, we should address the electronic waste (e-waste) management in order to avoid the problems that wasted batteries impose on environment.

The following policies are recommended to increase the rate of adoption of BEVs:

- Proposing attractive warranty and guaranty options to customers in order to decrease the perceived risk of using a BEV
- Proposing the creative options to customers in order to facilitate reselling the used battery electric vehicles in a market
- Developing BEV with completely different styles. Differentiating styles of BEV from conventional cars influence directly the rate of adoption of BEVs as our research results shows consumers would feel high social prestige when they use a BEV. People should realize the battery electric cars in streets very easily. Therefore, car manufacturers should design very attractive and different styles for BEVs.

In addition to offer financial incentives to promote buying of BEVs, change agents should address the following actions in order to facilitate the diffusion of BEVs in a market[13]:

- Creation of a dedicated EV government agency that would coordinate all government and municipalities efforts with regards to EVs
- Implement mandatory fuel economy standards
- Ensure building codes for new or renovated sites (residential, commercial, industrial)
- Firm national EV sales targets
- Connecting renewable energy targets to EV sales
- Common metric for lifetime cost comparison of ICEVs, HEVs and EVs
- Coordination federal and State EV strategies
- Managing grid capacity in peak period

[13] See: Supporting Electric Vehicle Adoption in Australia: Barriers and Policy Solution (2011)

7
Conclusion and Research Contribution

In previous chapters we explained the various steps that we took for doing this research from describing the research problem to proposing a roadmap and policies to accelerate the diffusion of battery electric vehicles in urban areas. In this chapter we review our research steps and findings and explain the main conclusions of our research. We also explain the practical and theoretical contributions of this research. In addition, some areas for further research in this field are proposed.

7.1 Research findings and conclusion

Purchasing a battery electric vehicle is a type of pro-environmental behavior but the impact of such behavior on the environment becomes significant and beneficial only if a large number of individuals buy it. Therefore, getting battery electric vehicles diffused in a social system is a critical task which needs a special attention from consumers as well as governments and suppliers. In order to fulfill this task, we need to at first find out the main factors influencing the diffusion of battery electric vehicles and the relative importance of each factor and then, based on these factors and the relative importance of them, develop a set of integrated solutions that accelerate the diffusion of battery electric vehicles.

Following the above logic, in this research, we tried to find out the all factors influencing the rate of adoption of a battery electric vehicles and the relative importance of each factor. Understanding these factors and the relative importance of them led us to propose a roadmap for diffusion of battery electric vehicles and a set of policies in different areas such as social, technology, infrastructure, business, and regulation that we believe if they are implemented effectively, they definitely accelerate the diffusion of battery electric vehicles. Undoubtedly, it is the responsibility of the people living in a social system, the governments, and the car manufacturers to collaborate with each other in order to implement the proposed policies in a cost effective way.

In order to find factors influencing the rate of BEV adoption, we pursued a deductive research strategy and chose theory of diffusion of innovation proposed by Rogers in 1962, 1985, and 2003 as our theoretical framework. Under this theoretical framework and by using the extensive literature on the diffusion of innovation theory, we developed a research model for diffusion of battery electric vehicles in which eleven factors influence the rate of BEV adoption. These factors are social pressure, social prestige, usefulness for environment, difficultly of use, price, perceived risk, knowledge and information, product availability, BEV performance, financial incentives and fuel cost savings. In order to test our model, we developed a questionnaire, tested its reliability and validity, and collected data by launching an online survey. In total, out of 438 responses, the 310 responses were acceptable and were used for data analysis.

Using the multiple regression analysis, we found seven factors significantly influence the rate of adoption of a battery electric vehicle including social pressure, social prestige, usefulness for environment, difficultly of use, price, perceived risk, and knowledge and information about battery electric vehicles. In addition, our

research shows that social pressure, social prestige and usefulness for environment are the most influential factors on the rate of BEV adoption.

In line with what Rogers (1962) has explained about the innovation-decision process, we substituted the attitude with the eight factors that we believe they are the determinants of attitude toward using a BEV including perceived risk, difficulty of use, social prestige, performance, fuel cost savings, usefulness for environment, knowledge and information, and financial incentives. The results of testing this model (attitude, social pressure, price, and product availability as predictors and intention to buy a BEV as outcome or dependent variable) showed that substituting attitude with these eight factors in the main model improved our research model in terms of explained variance of intention to buy a BEV from 48.7% to 53.2%. In addition, all factors except financial incentives significantly influence the attitude toward using a BEV. These findings confirmed that attitude plays as a mediator between seven factors including perceived risk, difficulty of use, social prestige, BEV performance, fuel cost savings, usefulness for environment, knowledge and information and intention to buy a BEV. This is completely in line with the theory of planned behavior proposed by Ajzen in 1985. According to Ajzen (1985), attitude toward a behavior, social pressure, and perceived behavioral control are the immediate determinants of the intention to do a behavior. In our research model, the above seven factors forms attitude toward using a BEV and price is the main perceived behavioral control item.

Based on our research findings, a roadmap for diffusion for battery electric vehicles was proposed. The main logic behind this roadmap is to use the potential benefits of social pressure, social prestige, and the positive perceptions of people about the usefulness of battery electric vehicle for environment as well as to address the main barriers to the widespread use of BEVs such as difficulty of use, price and perceived risk. This roadmap has four gates and four main processes. The

gates include kick off gate, price ready gate, infrastructure ready gate, and technology ready gate. The main processes are promotional efforts initiatives, infrastructure initiatives, technology enhancing initiatives, and increasing the knowledge and information about BEVs. The mechanism by which this roadmap works is simple and as follows: in order to use the potential benefit of social pressure, we need to generate a source of pressure in a social system. In other words, we need an initial momentum inside a city in which BEV adoption is supposed to take place. This source of pressure is innovators who are less concerned about the risk and difficulty of using a BEV. Therefore, targeting innovators and motivating them to buy a BEV through an attractive promotional offer is the first step in this roadmap. These innovators start pushing early adaptors to buy BEVs. At the same time, the infrastructure initiatives such as developing an extensive charging network should be started and gradually by appearing the outcomes of these initiatives, the early adaptors feel less risk and difficulty of using a BEV and begin considering and adopting a BEV. In the next step, the results of technology enhancing initiatives such as less charging time, more driving range, and less cost as well as the pressure from innovators and early adaptors motivate early and late majority to consider and buy BEVs.

In addition to the roadmap, a set of policies in order to accelerate the diffusion of battery electric vehicles in urban areas were proposed in this research. These proposed policies serve as general guidelines to develop a set of practical solutions for diffusion of battery electric vehicles. Clearly, each city based on its vision for deploying the battery electric vehicle fleet in its transportation system and other characteristics such as geographical, social, and economic conditions can translate this roadmap and guidelines into a practical program for diffusion of battery electric vehicles for its own.

In sum, the following conclusions can be drawn from our research on the diffusion of battery electric vehicles in urban areas:

- Social pressure, social prestige, and the belief that battery electric vehicles are useful for environment are the most important factors that positively influence the diffusion of battery electric vehicle in an urban area.
- Difficulty of use, price and perceived risk are the main barriers to the widespread use of battery electric vehicles.
- In order to have battery electric vehicles diffused in an urban area, it is very important to have a practical program which addresses both social and knowledge based factors such as social pressure, social prestige, and usefulness for the environment and the main barriers to the widespread use of battery electric vehicles such as difficulty of use, price, and perceived risk.
- Knowledge and information about various aspects of BEVs such as incentive programs, fuel cost savings, the total cost of ownership, the environmental benefits should be increase among the members of a social system through mass media, campaign, and other communication channels.
- Diffusion of battery electric vehicles in a social system needs a centralized management supported by a change agent (municipalities, governments, and etc.) which develops, implements, and controls all related projects for diffusion of battery electric vehicle in an urban area under a single program

7.2 Research contributions and suggestions for further research

From different points of view this research is useful and interesting. From practical point of view, the results of this research provide a roadmap and a set of policies which can accelerate the diffusion of battery electric vehicles in an urban area. The widespread use of battery electric vehicles in a social system can reduce ICEV emissions which are one of the main contributors to air pollution in urban areas. For countries such as Canada that the share of electricity generation from the clean sources has increased considerably in recent years, the effect of BEV diffusion on reducing the GHG emissions can be dramatic. In addition to reducing air pollution, running a lot of BEVs on streets decreases the total wasted energy of urban passenger car fleet due to higher efficiency of battery electric vehicles. From the knowledge gap point of view, our research on diffusion of battery electric vehicles has a lot of contribution to both researchers and practitioners working in this field.

First, according to Rogers (2003) only a little research has conducted to find out the relative importance of factors influencing the rate of adoption. Most of the research in the field of diffusion of innovation has only focused on the perceived attributes of innovation as the main independent variables and missed the other factors such as the social pressure and change agent promotional efforts. In this research we included all independent variables proposed by Rogers (1962, 1983, and 2003) and found the relative importance of each factor. Therefore, from this point of view our research has a lot of contribution.

Secondly, finding the social pressure, social prestige, and the belief that battery electric vehicles are useful for environment as the most important factors for diffusing BEV in a social system extends our knowledge in this field and also motivates researchers and practitioners in this field start rethinking about the power

of social based solutions on accelerating the diffusion of battery electric vehicles and even on green products to some extent. This finding is against the general understanding that price and infrastructure are the only main factors which should be addressed in order to accelerate the diffusion of battery electric vehicles. In fact, our research shows that the diffusion of battery electric vehicles in an urban area can potentially benefit from factors such as social pressure, social prestige, and consumers' perception about the usefulness of BEVs for environment.

Finally, in contrast to many research on diffusion, which has conducted after adoption of innovation (retrospective research) (Rogers, 2003; Tornatzky and Klein, 1982), our research on diffusion of electric vehicles had a chance to be conducted before the probable complete diffusion of electric vehicles (predictive research). Therefore, we had a chance to gather data in a neutral way. This helped us to overcome the pro – innovation bias which exists in many research in the field of diffusion of innovations. (Rogers, 2003)

Regarding to further research in this field, one of the areas for further research is to investigate about the profile of BEV innovators, early adaptors, early majority, late majority and laggards in order to find the customized solutions for each group of people. The other area that we recommend for further research is to conduct an empirical study to confirm the revised model that we proposed in this thesis. In the field of engineering, we suggest a research on charging stations BEV network design in province of Ontario in order to find the optimum cost for development of BEV infrastructure.

8
Appendices

8.1 Appendix 1: Preliminary Questionnaire

Questionnaire

The objective of this research:
The objective of this research is to discover the factors that influence consumers in their decisions about whether to purchase a Battery Electric Car within one year.

Definitions:
Battery Electric Car: This is a car that runs purely on electrical energy derived from batteries
Hybrid Electric Car: This is a car that runs both on electrical energy derived from batteries AND an internal combustion engine
Conventional Car: This is a car powered by an internal combustion engine only.

Age: 18-35□ 35-50□ 50+□

Gender: Male□ Female□

Education: Secondary School □ Post-Secondary Degree □

Living Status: Single (1 person) □ With a Family (2 people) □ With a Family (3-5 people) □ With a Family (5+ people) □

I am currently living in Ontario/Canada: Yes □ No □

I've owned a private vehicle for at least 2 years? Yes □ No □

Have you driven any kind of Electric Car (Hybrid, battery, and etc.) for more than 3 months? Yes □ No □

Do you currently own and drive any kind of Electric Car? Yes □ No □

Appendix 1: Preliminary Questionnaire

	Question	Strongly Disagree	Moderately Disagree	Slightly Disagree	Neither Agree Nor Disagree	Slightly Agree	Moderately Agree	Strongly Agree
-f1	I think the price of a Battery Electric Car compared to a Traditional Car is very high.							
-f1	The price of Battery Electric Car is reasonable.							
-f2	I think I gain good fuel cost savings if I use a Battery Electric Car.							
-f2	I think the maintenance cost of a Battery Electric Car is low compared to a Traditional Car							
-f2	Fuel cost savings is NOT good when I use a Battery Electric Car.							
-f3	It takes a long time (hours) to charge a Battery Electric Car.							
-f3	It is hard to find an auto repair shop that services a Battery Electric Car.							
-f3	Before I can drive a Battery Electric Car, I need to learn some driving instructions.							
-f3	I think I need to change my everyday life routines when I buy a Battery Electric Car.							
0-f3	Finding a charging station to charge my Battery Electric Car is easy.							
1-f4	I have a great deal of knowledge about the benefits of Battery Electric Car to environment.							
2-f4	I have a great deal of knowledge about how a Battery Electric Car works.							

3-f4	I have knowledge about the fuel cost savings that I gain if I use a Battery Electric Car.							
4-f4	I have information about the Battery Electric Car models and brands in market.							
5-f5	I think the current financial incentives and subsidies for buying a Battery Electric Car are enough.							
6-f5	The current financial incentives and subsidies for buying a Battery Electric Car are very low.							
7-f6	There are only a few Battery Electric Car models and brands in the market.							
8-f6	I feel I can find my favorite brand and model car if I want to buy a Battery Electric Car.							
9-f7	I feel a moral obligation NOT to use a Traditional Car no matter what other people do.							
0-f7	Personally, I feel that it is important to travel as little as possible by a Traditional Car.							
1-f7	I do NOT feel a moral obligation to use a Battery Electric Car.							
2-f8	People that mean a lot to me think that I should drive the Gasoline Vehicle as little as possible.							
3-f8	People close to me think that I should replace my vehicle with a Battery Electric Vehicle.							
4-f8	People that are important to me do NOT expect me to buy a Battery Electric Car.							

5-f9	I think there are effective laws and regulations against the use of Traditional Cars.							
6-f9	I think the current laws and regulations really promote the use of Traditional Cars.							
7-f9	There are NOT enough laws and regulations to promote the use of Battery Electric Cars.							
8-f10	I think the performance of a Battery Electric Car is currently at least the same as its Traditional counterpart.							
9-f10	The features of a Battery Electric Car are currently at least comparable to its Traditional counterpart.							
0-f10	I do NOT think the performance of a Battery Electric Car is good enough.							
1-f11	I think I would feel more social prestige if I use a Battery Electric Car.							
2-f11	I think I gain a social status if I use a Battery Electric Car.							
3-f12	I fear that I cannot charge a Battery Electric Car when I need to charge it.							
4-f12	I think it is very hard to sell a used Battery Electric Car.							
5-f12	I fear that a Battery Electric Car does not perform well.							

	Question	Definitely NOT	Probably NOT	Maybe	Probably	Definitely
6-f13	I will buy a Battery Electric Car within one year.					
7-f13	If I have the chance to buy a second car, the probability that I will buy a Battery Electric Car would be					

8.2 Appendix 2: Final Questionnaire

Consent Agreement

Title of Study: Factors influencing the rate of adoption of Battery Electric Vehicles in urban areas

You are being asked to participate in a research study. Before you give your consent to be a volunteer, it is important that you read the following information and ask as many questions as necessary to be sure you understand what you will be asked to do.

Investigators:

- Morteza Mashayekhi, MMSc Candidate in the Management of Technology and Innovation, Ted Rogers School of Management, Ryerson University.
- Professor Aziz Guergachi, Ted Rogers School of Management, Information Technology Department, Ryerson University

Purpose of the Study:

The objective of this research is to discover the factors that influence consumers in their decisions about whether to purchase a Battery Electric Vehicle within one year. The target population of this research is composed of all individuals who live in Ontario, and have a valid driving license and at least one year driving experience.

Description of the Study:

You are being asked to complete an online survey. The online survey consists of 23 questions. Each question includes one or more items. The items aim to find your knowledge, perception, and attitude toward using a Battery Electric Vehicle. All items are in a seven-point Likert type scale. It takes less than 15 minutes to complete this survey.

What is Experimental in this Study:

"None of the questionnaires used in this study are experimental in nature. The only experimental aspect of this study is the gathering of information for the purpose of analysis."

Risks or Discomforts:

The number of items in this survey may make you feel bored or discomfortable. If you feel bored or discomfortable at any time during participation at this survey, you can discontinue participation, either temporarily or permanently.

Benefits of the Study:

The results of this study are used as a basis to develop solutions for accelerating the diffusion of battery electric vehicles in the province of Ontario. We, as researchers of this study, believe that diffusion of battery electric vehicles has a lot of potential benefits to our society as it reduces air pollution in our province and decreases the dependence of our province on oil and gas. All these benefits can promote sustainable growth toward resource-efficient, low-carbon, and competitive economy for the province of Ontario. Obviously, the all above mentioned potential benefits of this study does not affect life of people living in Ontario and so participants of this study directly and in the short-time. Therefore, this study has no direct and short–time benefits to you as a participant of this study.

Confidentiality:

This online survey is anonymous.

Incentives to Participate:

If you are recruited by the CANADIAN VIEWPOINT COMPANY to participate in this research, you will be paid $2 (two dollars) if you are eligible and respond the all items in this survey. The time of payment depends on the contract between you and the CANADIAN VIEWPOINT COMPANY.

Voluntary Nature of Participation:

Participation in this study is voluntary. Your choice of whether or not to participate will not influence your future relations with Ryerson University. If you decide to participate, you are free to withdraw your consent and to stop your participation at any time without penalty or loss of benefits to which you are allowed.
At any particular point in the study, you may refuse to answer any particular question or stop participation altogether.

Questions about the Study:

If you have any question regarding this research please do not hesitate to contact Mr.Morteza Mashayekhi at: morteza.mashayekhi@ryerson.ca

If you have questions regarding your rights as a human subject and participant in this study, you may contact the Ryerson University Research Ethics Board for information.

Research Ethics Board
c/o Office of the Vice President, Research and Innovation
Ryerson University
350 Victoria Street
Toronto, ON M5B 2K3
416-979-5042

Agreement:

If you are interested in taking this survey please select the “I Agree” choice and continue to take the survey otherwise select the “I Do not Agree” choice to end the survey.
Thank you so much for your time and participation.

- ❍ I Agree (1)
- ❍ I Do not Agree (2)

If “I Do not Agree” Is Selected, Then Skip To End of Survey

Definitions:

Battery Electric Car: This is a car that runs purely on electrical energy derived from batteries.

Hybrid Electric Car: This is a car that runs both on electrical energy derived from batteries AND an internal combustion engine.

Conventional Car: This is a car powered by an internal combustion engine only (uses gasoline)

Q1: Age:

- 18-24 (1)
- 25-39 (2)
- 40-50 (3)
- 50+ (4)

Q2: Gender:

- Male (1)
- Female (2)

Q3: Education: What is the highest degree or level of school you have completed? If currently enrolled, mark the previous grade or highest degree received.

- Less than High School (1)
- High School degree/GED (2)
- Some College (3)
- Associate degree (4)
- Bachelor's degree (BA, BS) (5)
- Master's or Doctoral degree (for example: MA, MS, MEng, MEd, MSW, MBA, PhD) (6)
- Professional degree (for example: MD, DDS, JD) (7)

Q4: Living Status:

- Single (1 person) (1)
- With a Family (2 people) (2)
- With a Family (3-5 people) (3)
- With a Family (5+ people) (4)
- Other (For example: with a roommate) (5)

Q5: I am currently living in Ontario/ Canada:

- Yes (1)
- No (2)

If "No" Is Selected, Then Skip To End of Survey

Q6: I have a valid driving license and at least one year driving experience?

- Yes (1)
- No (2)

If "No" Is Selected, Then Skip To End of Survey

Q7: Have you driven any kind of Electric Car (Hybrid, battery, and etc.) for more than 3 months?

- ❍ Yes (1)
- ❍ No (2)

Q8: Do you currently own and drive any kind of Electric Car? (Hybrid or Battery Electric Car)

- ❍ Yes (1)
- ❍ No (2)

Q9: How much do you have knowledge and information about Battery Electric Cars? Please rate the following questions from "Very Little" to "Very Much"

	Very Little(1)	(2)	(3)	(4)	(5)	(6)	Very Much (7)
I have knowledge about the benefits of Battery Electric Car to environment. (1)	❍	❍	❍	❍	❍	❍	❍
I have knowledge about how a Battery Electric Car works. (2)	❍	❍	❍	❍	❍	❍	❍
I have knowledge about the fuel cost savings that I gain if I use a Battery Electric Car. (3)	❍	❍	❍	❍	❍	❍	❍
I have information about the Battery Electric Car models and brands in market. (4)	❍	❍	❍	❍	❍	❍	❍
I have information about the current price range of Battery Electric Car in market. (5)	❍	❍	❍	❍	❍	❍	❍
I have information about financial incentives offered by government to buy a Battery Electric Car (6)	❍	❍	❍	❍	❍	❍	❍
I have knowledge about the	❍	❍	❍	❍	❍	❍	❍

performance of a typical Battery Electric Car (Acceleration, power, safety, driving range). (7)							
I have knowledge about charging a Battery Electric Car (Charging options, charging time) (8)	❍	❍	❍	❍	❍	❍	❍

Q10: What do you think about the price of a Battery Electric Car?

	Much Lower (1)	Lower (2)	Somewhat Lower (3)	The Same (4)	Somewhat Higher (5)	Higher (6)	Much Higher (7)
I think the price of a Battery Electric Car compared to a similar Conventional Car is: (1)	❍	❍	❍	❍	❍	❍	❍

Q11: What do you think about the fuel cost savings you gain if you use a Battery Electric Car? Please rate the following questions from "Strongly Disagree" to "Strongly Agree"

	Strongly Disagree (1)	Disagree (2)	Somewhat Disagree (3)	Neither Agree nor Disagree (4)	Somewhat Agree (5)	Agree (6)	Strongly Agree (7)
I think I gain good fuel cost savings if I use a Battery Electric Car. (1)	❍	❍	❍	❍	❍	❍	❍
Fuel efficiency is very important for me when I want to buy a car. (2)	❍	❍	❍	❍	❍	❍	❍

Q12: What do you think about how risky it is to use a Battery Electric Car? Please rate the following questions from "Strongly Disagree" to "Strongly Agree"

	Strongly Disagree (1)	Disagree (2)	Somewhat Disagree (3)	Neither Agree nor Disagree (4)	Somewhat Agree (5)	Agree (6)	Strongly Agree (7)
I fear I have to pay more money for maintenance of a Battery Electric Car than a similar Conventional Car. (1)	❍	❍	❍	❍	❍	❍	❍
I fear that I CANNOT sell easily a used Battery Electric Car when I like to buy a new car. (2)	❍	❍	❍	❍	❍	❍	❍
I fear that a Battery Electric Car does not perform well. (3)	❍	❍	❍	❍	❍	❍	❍
I fear that I CANNOT charge a Battery Electric Car when I need to charge it. (4)	❍	❍	❍	❍	❍	❍	❍

Q13: What do think about financial incentives, subsidies, laws and regulations offered and enforced by government to promote buying a Battery Electric Car? Please rate the following questions from "Strongly Disagree" to "Strongly Agree"

	Strongly Disagree (1)	Disagree (2)	Somewhat Disagree (3)	Neither Agree nor Disagree (4)	Somewhat Agree (5)	Agree (6)	Strongly Agree (7)
I think the current financial incentives and subsidies for buying a Battery Electric Car are enough. (1)	❍	❍	❍	❍	❍	❍	❍
The current financial incentives and	❍	❍	❍	❍	❍	❍	❍

subsidies for buying a Battery Electric Car are NOT motivating. (2)							
I need more financial incentives and subsidies to buy a Battery Electric Car. (3)	❍	❍	❍	❍	❍	❍	❍
There are NOT enough laws and regulations to promote the use of Battery Electric Cars. (4)	❍	❍	❍	❍	❍	❍	❍

Q14: What do you think about the Battery Electric Car performance? Please rate the following questions from "Strongly Disagree" to "Strongly Agree"

	Strongly Disagree (1)	Disagree (2)	Somewhat Disagree (3)	Neither Agree nor Disagree (4)	Somewhat Agree (5)	Agree (6)	Strongly Agree (7)
I think the performance of a Battery Electric Car is at least the same as its similar Conventional Car. (1)	❍	❍	❍	❍	❍	❍	❍
I think performance of a Battery Electric Car may NOT be good. (2)	❍	❍	❍	❍	❍	❍	❍
Performance of a car (Acceleration, power, safety and etc.) is very important to me when I want to buy a car. (3)	❍	❍	❍	❍	❍	❍	❍

Q15: What do you think about the Battery Electric Car models, and brands in the market? Please rate the following questions from "Strongly Disagree" to "Strongly Agree"

	Strongly Disagree (1)	Disagree (2)	Somewhat Disagree (3)	Neither Agree nor Disagree (4)	Somewhat Agree (5)	Agree (6)	Strongly Agree (7)
There are only a few Battery Electric Car models and brands in the market. (1)	❍	❍	❍	❍	❍	❍	❍
I feel I can find my favorite brand and model if I want to buy a Battery Electric Car. (2)	❍	❍	❍	❍	❍	❍	❍
Typically when I want to buy a car I need to compare several models and brands in market. (3)	❍	❍	❍	❍	❍	❍	❍

Q16: What do you think about how easy or difficult it is to use a Battery Electric Car? Please rate the following questions from "Strongly Disagree" to "Strongly Agree"

	Strongly Disagree (1)	Disagree (2)	Somewhat Disagree (3)	Neither Agree nor Disagree (4)	Somewhat Agree (5)	Agree (6)	Strongly Agree (7)
It takes a long time to charge a Battery Electric Car. (1)	❍	❍	❍	❍	❍	❍	❍
The driving range of a Battery Electric Car is NOT enough. (2)	❍	❍	❍	❍	❍	❍	❍
I think I need to change my everyday life routines when I buy a Battery Electric Car. (3)	❍	❍	❍	❍	❍	❍	❍

If you are still paying attention to this survey please select "strongly agree" choice. (4)	❍	❍	❍	❍	❍	❍	❍
Finding a charging station to charge my Battery Electric Car is easy. (5)	❍	❍	❍	❍	❍	❍	❍
There are not enough charging stations in cities	❍	❍	❍	❍	❍	❍	❍
It is hard to find an auto repair shop that services a Battery Electric Car. (6)	❍	❍	❍	❍	❍	❍	❍

Q17: Do you feel any social pressure to buy a Battery Electric Car? Please rate the following questions from "Strongly Disagree" to "Strongly Agree"

	Strongly Disagree (1)	Disagree (2)	Somewhat Disagree (3)	Neither Agree nor Disagree (4)	Somewhat Agree (5)	Agree (6)	Strongly Agree (7)
People that mean a lot to me think that I should use a Battery Electric Car instead of a Conventional Car. (1)	❍	❍	❍	❍	❍	❍	❍
People close to me think that I should replace my car with a Battery Electric Car. (2)	❍	❍	❍	❍	❍	❍	❍
People that are important to me expect me to use a Battery Electric Car instead of a Conventional Car. (3)	❍	❍	❍	❍	❍	❍	❍

Q18: Do you feel that you are morally obligated to use a Battery Electric Car? Please rate the following questions from "Strongly Disagree" to "Strongly Agree"

	Strongly Disagree (1)	Disagree (2)	Somewhat Disagree (3)	Neither Agree nor Disagree (4)	Somewhat Agree (5)	Agree (6)	Strongly Agree (7)
I believe using a Battery Electric Car is useful for environment. (1)	❍	❍	❍	❍	❍	❍	❍
I really care about the environment and try to save it from air pollution. (2)	❍	❍	❍	❍	❍	❍	❍
I am partly responsible for the fossil oil problems in society today (3)	❍	❍	❍	❍	❍	❍	❍
I feel partly responsible for the increase in the use of fossil fuels such as oil/gasoline/diesel (4)	❍	❍	❍	❍	❍	❍	❍
I feel partly responsible for global warming (5)	❍	❍	❍	❍	❍	❍	❍
I feel a moral obligation to use a Battery Electric Car. (6)	❍	❍	❍	❍	❍	❍	❍
I would be a better person if I used a Battery Electric Car. (7)	❍	❍	❍	❍	❍	❍	❍
If I were to replace my car today I would feel a moral obligation to replace it for a Battery Electric Car. (8)	❍	❍	❍	❍	❍	❍	❍

Q19: How would you feel if you use a Battery Electric Car? Please rate the following questions from "Strongly Disagree" to "Strongly Agree"

	Strongly Disagree (1)	Disagree (2)	Somewhat Disagree (3)	Neither Agree nor Disagree (4)	Somewhat Agree (5)	Agree (6)	Strongly Agree (7)
I think I would feel more social prestige if I use a Battery Electric Car. (1)	❍	❍	❍	❍	❍	❍	❍
I think I gain a social status if I use a Battery Electric Car. (2)	❍	❍	❍	❍	❍	❍	❍
I would feel so proud of myself when I use a Battery Electric Car. (3)	❍	❍	❍	❍	❍	❍	❍

Q20: How much are you willing to pay more to buy a Battery Electric Car than to buy a similar Conventional Car?

	Nothing (1)	Less than $1000 (2)	Between $1000 and $2000 (3)	Between $2000 and $3000 (4)	Between $3000 and $4000 (5)	Between $4000 and $5000 (6)	More than $5000 (7)
I am willing to pay more to buy a Battery Electric Car than to buy a similar Conventional Car. (1)	❍	❍	❍	❍	❍	❍	❍

Q21: Considering your expected using a Battery Electric Car, what is the longest time to fully recharge the battery (at home) that you would consider acceptable when buying or leasing a Battery Electric Car?

	10 hours or less (1)	8 hours or less (2)	6 hours or less (3)	4 hours or less (4)	2 hours or less (5)	1 hours or less (6)	30 minutes or less (7)
The longest time to fully recharge the battery (at home) that I would consider acceptable is: (1)	❍	❍	❍	❍	❍	❍	❍

Q22: What is your attitude toward using a Battery Electric Car?

	Strongly Disagree (1)	Disagree (2)	Somewhat Disagree (3)	Neither Agree nor Disagree (4)	Somewhat Agree (5)	Agree (6)	Strongly Agree (7)
For me, to use a Battery Electric Car is pleasant. (1)	❍	❍	❍	❍	❍	❍	❍
My attitude toward using a Battery Electric Car is positive. (2)	❍	❍	❍	❍	❍	❍	❍
I like to use a Battery Electric Car. (3)	❍	❍	❍	❍	❍	❍	❍

Q23: Do you consider buying or leasing or intend to buy or lease a Battery Electric Car?

	Definitely Not (1)	Very Much Likely Not (2)	Likely Not (3)	No Decision (4)	Likely (5)	Very Much Likely (6)	Definitely (7)
I am willing to consider buying or leasing a Battery Electric Car. (1)	❍	❍	❍	❍	❍	❍	❍
I intend to buy or lease a Battery Electric Car a year from now. (2)	❍	❍	❍	❍	❍	❍	❍
If I have the chance to buy a second car, I am willing to buy or lease a Battery Electric Car. (3)	❍	❍	❍	❍	❍	❍	❍

9
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