



National  
College *of*  
Ireland

**RESEARCH ON SCOPE AND FUTURE OF BATTERY  
ELECTRIC VEHICLES IN IRELAND – A CASE STUDY**

**Rohan Yerdoni Desai**

**x19132972**

**MSc In International Business**

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# Submission of Thesis and Dissertation

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**Name: Rohan Yerdoni Desai**

**Student Number: x19132972**

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## **Abstract**

With the increase in pollution levels by using Internal Combustion Engine (ICE) vehicles and of fossil fuels, the best alternative source to ICE vehicles is to drive Electric vehicles which does not harm the environment by emitting harmful gases. The level of carbon dioxide and carbon monoxide in the air is very high and hence initiatives should be undertaken to make a better tomorrow by availing the alternative possible (Mukherjee et al., 2020). Collectively, all the vehicles with IC engines contribute to 24% of global warming in United States of America and a major contributor across the whole world.

This dissertation is concentrated on giving a crystal-clear view of how the socio-demographic factor, demand-pull will influence global Electric Vehicle market as well as BEV market in Ireland (He et al., 2020).

This dissertation is about the study of global EV market, the current market scenario as well as the future of BEV in Ireland. The dissertation concentrates mainly on three important points.

This dissertation gives a detailed view of the strategies implemented by the experts to encourage the sale of EV. Both primary and secondary data has been used for this dissertation.

## **Acknowledgement**

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Lastly, I would like to thank my parents and friends who have been providing me constant support for all my works.

## **List of Abbreviations**

<b>BEV</b>	= Battery Electric Vehicle
<b>CCC</b>	= Cell Cooling Coefficient
<b>CSO</b>	= Central Statistics Office
<b>DOF</b>	= Degree of Freedom
<b>EV</b>	= Electric Vehicle
<b>ESB</b>	= Emergency Starting Battery
<b>ICE</b>	= Internal Combustion Engine
<b>MNL</b>	= Multinomial Logic
<b>PHEV</b>	= Plug-in Hybrid Electric Vehicle
<b>PEV</b>	= Plug-in Electric Vehicle
<b>SEAI</b>	= Sustainable Energy Authority of Ireland
<b>SIMI</b>	= Society of Irish Motor Industry
<b>SPSS</b>	= Statistical Package for Social Sciences
<b>VRT</b>	= Vehicle Registration Tax

## Table of Contents

CHAPTER 1: INTRODUCTION .....	10
1.1 RESEARCH BACKGROUND .....	10
1.1.1 INTERNATIONAL BEV MARKET .....	11
1.1.2 IRELAND BEV MARKET .....	13
1.1.3 GOVERNMENT BEV BENEFITS .....	14
1.2 RESEARCH AIM .....	15
1.3 RESEARCH OBJECTIVES .....	15
1.4 STRUCTURE OF THESIS .....	15
CHAPTER 2: LITERATURE REVIEW .....	16
2.1 ELECTRIC VEHICLE GLOBAL MARKET .....	16
2.1.1 BEV MARKET OVERVIEW OF USA AND CHINA .....	16
2.1.2 EV MARKET OF CHINA AND EUROPE .....	18
2.1.3 IRELAND BEV MARKET .....	19
2.2 BEV TECHNOLOGICAL FACTORS .....	19
2.2.1 ELECTRIC VEHICLE TYPES .....	19
2.2.2 BEV USAGE PATTERN .....	20
2.3 BEV CHARGING INFRASTRUCTURE AND PRICE .....	21
2.3.1 GLOBAL SCENARIO .....	21
2.3.2 IRELAND CHARGING INFRASTRUCTURE SCENARIO .....	21
2.4 COST COMPARISON .....	22
2.4.1 CHARGING PRICE COMPARISON .....	22
2.4.2 CHARGING PRICE COMPARISON IN IRELAND .....	22
2.5 SOCIO DEMOGRAPHIC FACTORS .....	22
2.6 RESEARCH GAP .....	23
2.7 THE RESEARCH MODEL & HYPOTHESIS SUMMARY .....	23
CHAPTER 3: METHODOLOGY .....	24

3.1 INTRODUCTION .....	24
3.2 RESEARCH POPULATION AND SAMPLING .....	25
3.2.1 RESEARCH POPULATION.....	25
3.2.2 SAMPLING METHOD .....	25
3.3 THEORY DEVELOPMENT.....	27
3.3.1 MULTINOMIAL LOGIC (MNL) .....	27
3.3.2 BEST-WORST DATA SCALING .....	28
3.4 RESEARCH MODEL .....	29
3.4.1 SOCIO DEMOGRAPHIC FACTORS .....	30
3.4.2 TECHNOLOGICAL FACTORS .....	30
3.4.3 DEMAND-PULL FACTORS.....	30
3.4.4 EV INFLUENCING ATTRIBUTES .....	30
3.5 DATA COLLECTION .....	31
3.5.1 PRIMARY DATA COLLECTION .....	31
3.5.1.1 VARIABLES SET 1 .....	31
3.5.1.2 VARIABLES SET 2 .....	32
3.5.1.3 MULTICHOICE OPTIONS .....	34
3.5.2 INFORMATION DERIVED THROUGH SECONDARY SOURCES .....	36
3.5.2.1 DENSITY ANALYSIS.....	37
3.6 DATA ANALYSIS.....	37
3.6.1 COMPONENT FACTOR ANALYSIS .....	37
3.6.2 RELIABILITY ANALYSIS .....	38
3.6.3 TWO WAY ANOVA .....	38
3.6.4 ONE SAMPLE T – TEST.....	40
3.7 ETHICS.....	40
CHAPTER 4: RESEARCH RESULTS .....	41
4.1 INTRODUCTION .....	41

4.2 DESCRIPTION OF RESULT .....	41
4.2.1 SOCIO-DEMOGRAPHIC VARIABLES .....	41
4.2.1.1 AGE AND GENDER .....	41
4.2.1.2 PROVINCE.....	42
4.2.1.3 ANNUAL INCOME.....	43
4.2.1.4 EDUCATION .....	43
4.2.1.5 OCCUPATION.....	44
4.2.2 TECHNOLOGICAL FACTORS .....	44
4.2.2.1 CAR MODEL .....	45
4.2.2.2 REGISTRATION TYPE .....	47
4.2.2.3 CHARGING PREFERENCE .....	47
4.2.2.4 AVERAGE DRIVING AND MAINTENANCE COST .....	48
4.2.2.5 SAFETY .....	49
4.2.2.6 DRIVING BEHAVIOR CHANGE .....	50
4.2.3 DEMAND PULL FACTORS .....	51
4.2.3.1 GOVERNMENT INCENTIVES RATINGS.....	51
4.2.3.2 SOCIAL REINFORCEMENT.....	51
4.2.3.3 ENVIRONMENTAL AWARENESS .....	52
4.2.4 INFLUENCING FACTORS.....	53
4.2.4.1 RESEARCH BEFORE PURCHASING.....	53
4.2.4.2 FACTORS BEHIND PURCHASE .....	54
4.2.4.3 IMPROVING CHARGING EXPERIENCE .....	56
4.2.4.4 IMPROVEMENT FACTORS OF ADOPTION.....	57
4.3 COMPONENT FACTOR ANALYSIS .....	58
4.3.1 SOCIO-DEMOGRAPHIC VARIABLES .....	59
4.3.2 DEMAND PULL FACTORS .....	64
4.3.3 TECHNOLOGICAL FACTORS.....	67



4.4 RELIABILITY ANALYSIS .....	70
4.4.1 DEMAND PULL FACTORS .....	70
4.5.2 ONE SAMPLE T TEST .....	71
4.5.3 MULTIPLE-CHOICE SELECTED 1 .....	72
4.5.4 MULTIPLE-CHOICE SELECTED 2 .....	72
4.5.5 MULTIPLE-CHOICE SELECTED 3 .....	73
4.6 TWO WAY ANOVA .....	73
CHAPTER 5: DISCUSSION & CONCLUSION .....	80
5.1 EV DISCUSSION ON GLOBAL EV MARKET – CHINA & U.S.A.....	80
5.2 SOCIO-ECONOMIC PROFILES OF EV OWNERS .....	81
CHAPTER 6: RECOMMENDATIONS AND POTENTIAL DEVELOPMENTS OF THE RESEARCH.....	84
6.1. RECOMMENDATIONS FOR FUTURE RESEARCH WORK .....	84
6.2.1 RECOMMENDATIONS TO THE GOVERNMENT and SIMI.....	85
6.3 LIMITATION .....	86
REFERENCE.....	87

## List of figures

Fig 1.1: Comparison of Various Vehicle Types .....	11
Fig 1.2: Global BEV and PHEV adoption year wise.....	12
Fig 1.3: Registration licensed for first time and imported private cars .....	13
Fig 1.4: Charging points infrastructure.....	14
Fig 2.1: Hypothesis summary .....	23
Fig.3.1: Flow diagram of the research strategy.....	24
Fig.3.2: Research Model .....	29
Fig. 3.3: Additional adoptions of EVs in Ireland over time.....	36
Fig.3.4: Density Analysis.....	37
Fig.4.1: Age & Gender of respondents .....	41
Fig.4.2: Ireland Provinces .....	42
Fig.4.3: Annual income.....	43
Fig.4.4: Education.....	43
Fig.4.5: Occupation.....	44
Fig.4.6: Car model .....	45
Fig.4.7: Registration type.....	47
Fig.4.8: Urban area charging preference.....	47
Fig.4.9: Remote area charging preference .....	48
Fig.4.10: Drive per week and maintenance cost .....	49
Fig.4.11: Safety in BEV.....	49
Fig.4.12: Change in driving behaviour as per car model.....	51
Fig.4.13: Satisfaction of Irish government benefits.....	51
Fig.4.14: Satisfaction of Social reinforcement .....	52
Fig.4.15: Awareness of the environment .....	53
Fig.4.16: Selections available before purchase.....	54
Fig.4.17: Selections of factors for adoption.....	55
Fig.4.18: Selections of factors for improving the charging experience .....	56
Fig.4.19: Improvement factors for future mass adoption .....	57
Fig.4.20: Scree plot of Socio-demographic variables.....	60
Fig.4.21: Scree plot of demand-pull factors.....	66
Fig.4.22: Scree plot of technological factors .....	69

## **CHAPTER 1: INTRODUCTION**

This part contains the foundation of the exploratory data analysis to give an outline of electric vehicles and related terms. Measurable information related to the global BEV market and details of factors playing key roles in Ireland's BEV selection gives the examination and comprehension of BEV reception (Tran et al., 2020). Exploration points and goals characterize the examination work of the paper. The factors of time, cost, and project management segments give an outline of the work.

### **1.1 RESEARCH BACKGROUND**

The BEV (Battery Electric Vehicle) trend has been expanding since 2000. However, the concept came into being with the usage of electric engines in a taxi in London and New York which recorded a speed of 106 Km/h. In the process of the innovations in the ICE segment, there have been upgrades in the few segments of BEV as well between 2000 to 2010. Precisely the sales related to battery vehicles has catered towards the contribution in tipping over the 2 million vehicle mark in the year 2019, for the first time. After 2010, BEV sales kept increasing rapidly year on year, and total EV sales grew by 80% in 2019 compared to 2018. In 2020, the number of EV in the world is estimated to be approximately 8.5 million (Huber et al., 2020). As demonstrated in the chart of per country selection of BEV, China is the BEV pioneer in the electric car market (Huber et al., 2020).

Figure 1 displays remarkable highlights of EV innovations, which is expressed in the following segment 1.1.2. With the fundamental point being to decide likely drivers for the reception of electric vehicles, module electric vehicles and Plug-in-Hybrid (PIH) vehicles are looked at as the two offers of battery charging segment vehicles. Cross breed EV and Fuel cell EV are not the same as Plug-in EV as they do not need battery charging (Anselma et al., 2020).

Characteristic	Hybrid EV (HEV)	Plug-in Hybrid (PIH)	Fuel cell EV (FCEV)	Plug-in EV (Plug-in EV)
Electric motor	Less powerful than PIH/EV	More powerful as compared to HEV	Electric traction motor	EV solely rely on electric motor
Battery Size	Small batteries	Battery size is greater than HEV	Small batteries	Battery size is greater than PIH
Tailpipe emissions	Less tailpipe emissions as compared to ICV	Less tailpipe emissions as compared to HEV	Zero tailpipe emissions	Zero tailpipe emissions
Running cost	Lower cost as compared to ICV	Lower cost as compared to HEV and ICV	Lower cost as compared to PIH	Lower cost as compared to PIH
Purchase price	Expensive compared to ICV	Expensive compared to HEV	Expensive compared to HEV	Expensive compared to HEV
Time to recharge batteries	Same as ICV; Cannot recharge batteries	Same as ICV, Fast charger can charge to 80% battery capacity in 30 mins	Same as ICV; Hydrogen fuel tanks are replaced	Fastest charger option: 15 mins to 30 mins Other options: 1.5 hours-8 hours
Home charging	No	Yes	No	Yes
Range anxiety	No range limitation	No range limitation	No range limitation depends on fuel tank size	Limited range
Brands available in WA	Toyota Prius, and Toyota Camry	Holden Volt	N/A	Nissan Leaf; Mitsubishi iMiEV

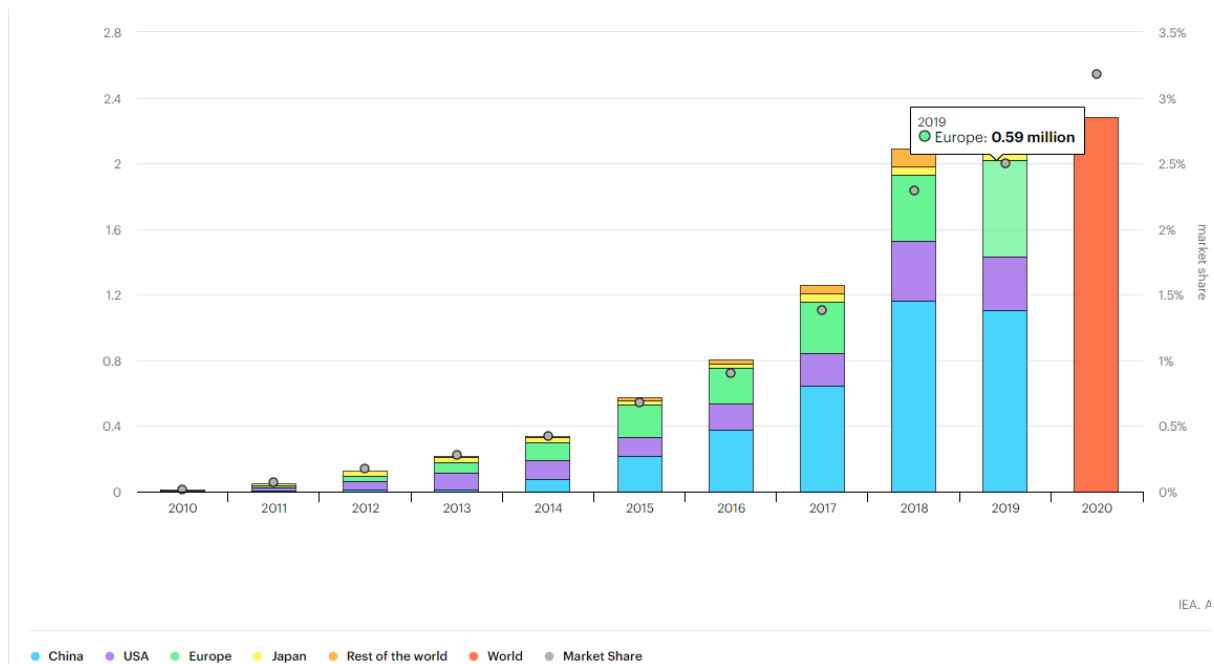
**Fig 1.1: Comparison of Various Vehicle Types**

(Source: Kantute, Deshmukh, & Kulkarni, 2009)

The above table represents the comparison between Hybrid EV, Plug-In Hybrid, Fuel EV, and Plug-in EV.

### 1.1.1 INTERNATIONAL BEV MARKET

As demonstrated in the diagram of BEV and PHEV selection in the global point of view, the electrical auto market was as low as insignificant from 2010 to 2013. But after 2014, the electrical market of the USA expanded, which impacted different nations for the reception of different types of EVs (Zhang et al., 2020). Chinese mechanical progression and public procedure expanded the quantity of BEV in the middle of 2016 to 2019. According to information, in 2019; China has become the world leader in the selection of BEV and Europe has followed in the subsequent position.



**Fig 1.2: Global BEV and PHEV adoption year wise**

(Source: IEA, 2020)

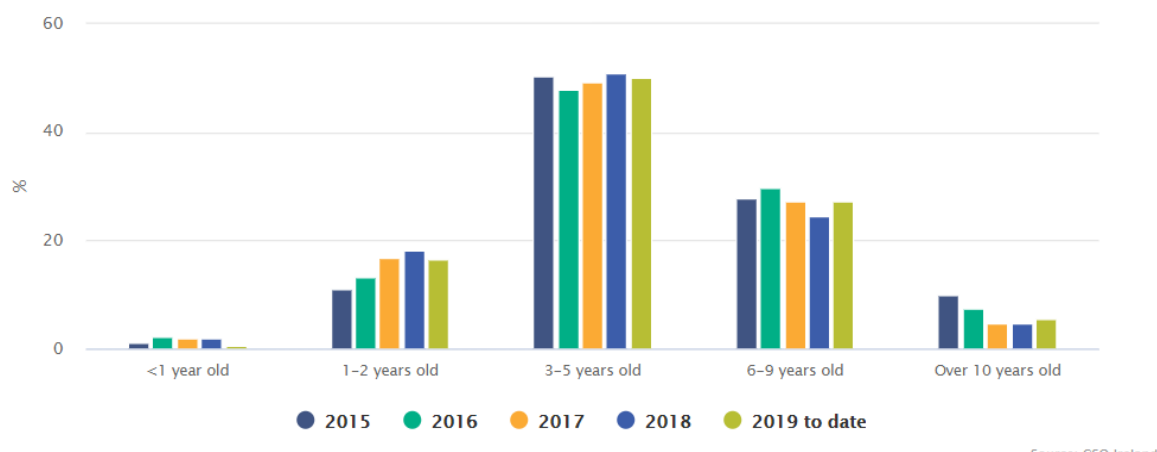
In the above figure, comparisons of Global BEV and PHEV adoption have been shown in terms of percentages.

After the ceaseless addition in BEV, the vehicle market actually had significant ICE vehicles. In the electric market, only China has been well known in the last 5 years and forecasted insights show a significant growth. Japan and America are at a constant pace of selection on the grounds that there was no development except in European nations. Netherlands is one of the top nations for the EV market (Kim et al., 2020). It has joined the likes of Norway, Iceland, and Sweden for the record growth of EV sales in the recent past. In the Netherlands, in 2020, 21% of the newly registered vehicles are BEV and 4% of the newly registered vehicles are PHEV. The figures indicate that EVs are rapidly taking over the ICE vehicle market in the Netherlands. The United Kingdom, Germany and Sweden have also expanded their EV growth over the recent years whereas in India, South Korea and Norway development was expanding step by step (Worldwide EV Outlook 2019 – Analysis, 2020). Nations everywhere in the world showing their aims of participating in the change from petroleum derivative vehicles to EV.

The UK asserted it would end all deals of non-renewable energy source vehicles by 2040 after France communicated comparable aspirations. India expressed it needs to replace all petroleum product vehicles with electric vehicles by 2030. Norway, Finland, and Sweden have further offered comparative expressions.

### 1.1.2 IRELAND BEV MARKET

There are 2,729,001 enlisted vehicles in 2019 that incorporate all sorts of vehicles (Erick et al., 2020). There are more than 17,000 PHEV and BEV on roads. In battery electric, there are 9452 number of BEV according to Aug 2020 SIMI information. In the enlistment of BEV, both new and utilized vehicles are outlined.

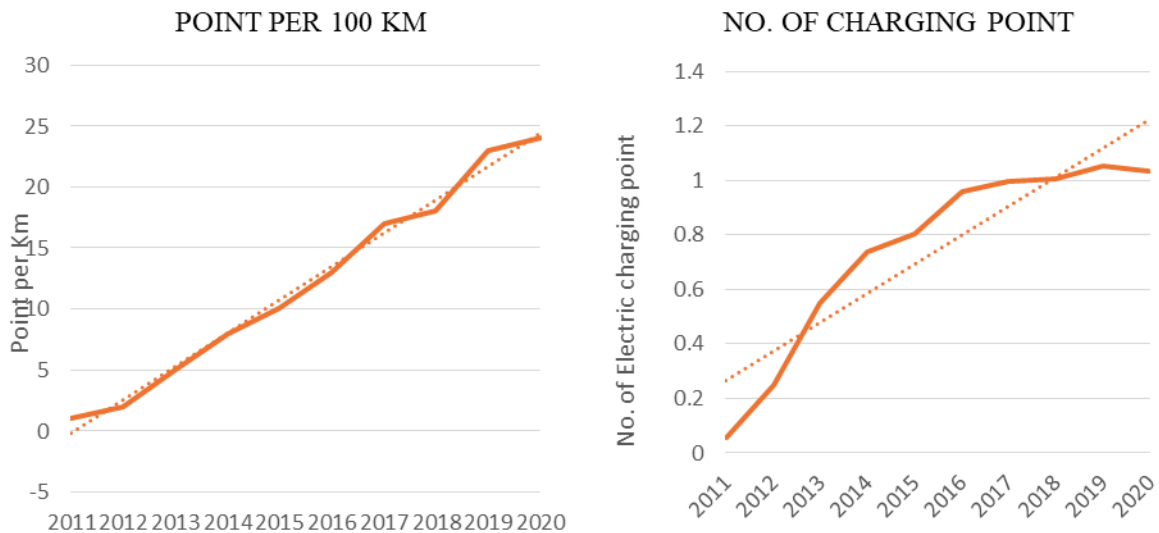


**Fig 1.3: Registration licensed for first time and imported private cars**

(Source: CSO, 2019)

**The above figure shows comparison of new registration and imported private cars**

Due to less accessibility and inclination of trade-in vehicles in Ireland; the charging framework of Ireland has been growing strongly (Nicoletti et al., 2020). Government motivates in-home charging, and the number of public charging points has expanded year on year. Moreover, the Sustainable Energy Authority of Ireland (SEAI) in this aspect introduces a grant of €5,000 for purchasing BEV (Electric Vehicle Grant Scheme, 2021). Such initiatives have the effectiveness for developing the numbers of BEV in the Irish market. However, it is noted that the production cost is very high for BEV which creates problems for the Irish market. Moreover, as per the viewpoint of Miller (2020), different European carmakers faced challenges in developing battery electric vehicles in the proper price range.



**Fig 1.4: Charging points infrastructure**

(Source: CSO, 2019)

### 1.1.3 GOVERNMENT BEV BENEFITS

Charging per 100 km has expanded over the recent years in some of the European countries on the highways through public charging points. Fast chargers are mostly situated within the urban corridor extending from Southern United Kingdom to Netherlands through south Germany, Switzerland, and German Rhineland (European Federation for Transport and Environment AISBL, 2020). Moderate and quick open chargers' numbers have expanded between the years 2013 to 2018. However, after that, the number of charging points have not expanded (Xu et al., 2020). Over the last 2 years, charging point's augmentation was not sharp when compared with previous years.

The public authority is giving a subsidy as much as 5000 € towards the buying cost of BEV in private buyers and as much as 3800 Euro for business reasons. The greatest award of PHEV is 2500 euro for new enlistment. BEV's VRT (Vehicle Registration Tax) is zero in Ireland and engine duty's most minimal rate is 120 Euro a year.

Emergency Starting Battery (ESB) is the type of battery which helps in wiper and AC functioning when the main battery is running. When the charge runs out in the main battery, the ESB can be utilized to start the vehicle.

## 1.2 RESEARCH AIM

The examination makes four commitments to explore work. To begin with, the majority of the work has dissected non EV drivers or PHEV drivers by thinking about a couple of components. In this examination, it centres around Socio-segment, innovative, influencing factors for selection which incorporates for most part totally thought to be point of view with BEV appropriation rate (Choi et al., 2020). Second, there were 20 factors considered and the impact of every factor for breaking down BEV reception. Third, the investigation of enumeration information for non EV drivers and charging focuses to distinguish the ICE driver's discernment for BEV reception. Fourth, the suggestions and recommendations have been made for the growth of BEV in Ireland.

## 1.3 RESEARCH OBJECTIVES

Research objectives are defined as below:

**Objective 1:** To analyse what is the scope of variables that impact the buying of BEV (Battery Electric Vehicle) by Irish consumers.

**Objective 2:** The experience and view of the individuals who have received/bought BEV in 2019.

**Objective 3:** To recommend incentives and practices that might encourage further BEV adoption.

## 1.4 STRUCTURE OF THESIS

**Chapter 2:** The research work incorporates past writing to comprehend the strategies and factors by different specialists.

**Chapter 3:** Methodology incorporates the model and variable sorts.

**Chapter 4:** Results incorporates the result of information assortment, factual examination, part factor investigation, dependability examination, Two-way ANOVA and one example T-test.

**Chapter 5:** Conclusion incorporates the end of outcomes, contrasts, and targets.

**Chapter 6:** Future work, proposal and limitations incorporated which are not covered in this exploration work and give an idea to future examination work.

The index gives the full data of SPSS Gantt diagram, Meeting structures, Graphs, Ethic structures and logbook.



## **CHAPTER 2: LITERATURE REVIEW**

Research on any topic can be done only by reviewing past work of topic for understanding and gaining knowledge. This section incorporates a survey on socio-segment factors, persuasive factors, BEV market research, charging points and framework and driving impacts. Besides, the writing of strategies and examination additionally included showing the purpose for adjusting procedures (Baskar et al, 2020). The examination legitimizes investigating BEV adaptation in Ireland. In conclusion, the research gap justifies researching BEV monetization in Ireland.

### **2.1 ELECTRIC VEHICLE GLOBAL MARKET**

#### **2.1.1 BEV MARKET OVERVIEW OF USA AND CHINA**

The analysed monetary and mechanical key components which influenced the USA's business EV market in 2012. Energy costs were as fuel (petroleum/diesel) expenses according to the market in the USA around then. In the buying cost, EVs were more expensive than traditional vehicles and maintenance cost was insignificant if battery substitution at long-span was kept away from. The truck type was considered based on age, price tag, energy utilization, and energy cost (Xie et al., 2020). In the original investment investigation, general elements, EV variables and diesel vehicle factors were thought of. In the flexibility investigation, how factors impact the limited cost was dissected. From all the examination, it was inferred that if trucks travel in excess of 16,000 miles each year, then electrical innovation will lessen the cost by 9-27% and will expand the opposition between motor vehicles and battery-worked vehicles. (Feng and Figliozzi et al., 2013).

Public endowments have been utilized generally to advance the enterprises which are manageable or relied upon for future innovation. The impacts of buyer and producer government motivators on the development of the BEV market in the USA (Dong et al., 2020). Information was gathered from true assets of the USA vehicle market – 2010. The specialist-based re-enactment model was worked to completely consider the heterogeneous components of clients and makers in dynamic (Song, R. and Potoglou, D., 2020). In the after-effect of the re-enactment, projected 2010 – 2050 recreation under three conditions – First, purchaser and production endowment situation in which if government does not give sponsorship or does not assume any part, then according to the dispersion of advancement hypothesis it might take few more years arrive in the EV market. Second, the purchaser sponsorship situation, Subsidy spans

and populace of EV significantly affected early EV adopters. Appropriation power and legitimacy span were the significant factors in this re-enactment. Thirdly, the loose impact will create an appropriate situation that may expand the R&D in the EV fragment and that might result in increment of deal volume following 10 years. This recreation had been performed under the US Vehicle market state of 2010 and considering the coming future. The thought about the new information on the market of the United States had also been considered alongside (Sun et al., 2019).

Large scale manufacturing EV market has been crucial to satisfy the need due to worldwide deals of 0.5 million vehicles in 2014 which has risen to 5.6 million vehicles in 2019. Assessed yearly deals in 2025 will be 10 million, 28 million by 2030, 56 million by 2040 (Shu et al., 2020). It was examined by the assembling of flow batteries and free crude material to identify the interest and supply of electric vehicles. Hence, the hazard in supply of mining materials can cause the fixation damage by influencing EV portion. Lithium, Cobalt, Nickel, and Manganese – abuse of these materials will make material shortage after 2030 which will have an effect in expanding the cost of EV. Rivalry between China, USA and Europe was condemned to gauge the future predominant of the electric vehicle industry (Jetin et al., 2020).

The author uncovers that the Chinese auto industry had not accomplished the ideal EV market in China even after the government incitement and arrangements (Jetin et al., 2020). Effect of government arrangements in China was created on various fundamental conditions - static outflow and sponsorships, dynamic discharge, endowments, dynamic emanation, and static appropriations. These situations were likewise incorporated with customer interest and vehicle supply to comprehend the effects more readily (Shi et al., 2020). The steady procedure of the game among government and vehicle produce was inferred and analysed. These outcomes showed that there was no steady procedure between game players since when the government would execute dynamic tax assessment or appropriation technique to stable conditions. A situation of dynamic tax assessment and static sponsorships was ideal for the EV business improvement (Liu, Huang and Yang et al., 2017).

### **2.1.2 EV MARKET OF CHINA AND EUROPE - COMPARISON**

Authors contrasted Chinese and European EV fragments with the plan of action and biological system of nearby firms. Subjective information from OEM, vehicle firms, data innovation firms' delegates were gathered by following the examination system. The exploration system was created on the premise of the organization's component factors and primary variables. Organization's elements incorporate stage sorting (network represented, centre business measure), foundation design (strategy adaptability, social adaptation) and primary variables incorporate inventory and in conclusion intermediates like establishments, government, or industry affiliation (Jin et al., 2020). This system had the option to exhibit the construction of business including supply, halfway – vision and mission and ultimately business setup. Characterized four situations of EV market dependent on a diagram of target market and development degree. It is suggested that future approach suggestions for Europe's standard and specialty market. To advance the EV, the government should give advantages, for example, VAT free vehicles, charge reclamation and awards. Expanding the charging framework and free charging in some European nations will likewise improve the EV market. From the viewpoint of Rong et al., (2017), it is identified about the growing popularity of EV in developing nations.

As per the viewpoint of Cheng (2020), the Chinese automotive industry introduces electric vehicles as a part of the potential ecosystem which includes ride hailing and self-driving cars. End of high contamination and high mechanical alteration was the public procedure to advance the EV business. It was investigated that the primary advances and the EV business to give future ramifications to the policymakers in 2016 - 2020. In the worldwide business sectors lightweight application and comfort in driving has been trending which pulled in more IT firms with vehicle firms. Chinese government began advancing EV from 2000, during 2001-2005 the government built up the premise of EV, during 2006 – 2010 government put PHEV in general society and private transportation, during 2011 – 2015 government began advertising EV. In order to support the engines and battery of EV, foothold batteries, foothold engines, power train, and energy units are introduced. PHEV has been utilized as reach extenders in the beginning period of the EV industry yet after the 2015; BEV has been extemporized (Liu et al., 2020). Liu et al., (2020) have also mentioned that power train improvement, high force hardware, energy components and coupler gadgets advancement have

developed different EV in the Chinese market. They prescribed to build up the footing battery innovation guide, energy component stack upgrades for advancing PHEV for range extenders and lower costs, new light weight undercarriage plans and recycled utilization of batteries – to improve the Chinese market to contend the worldwide patterns for what is to come (Du, Ouyang and Chen, 2017).

### **2.1.3 IRELAND BEV MARKET**

Wagner (2021) has identified that the registration of electric vehicles is 4,013 units in Irish market. A gathered information from SIMI and SEAI official hotspots for the looking at new and old EV enlistment in Ireland and organized meetings with the government (Tao et al., 2020). Topical heading from the information assortment were mechanical/modern elements, monetary variables, instructive and hierarchical components. In the proposal, recommendation was made for new design of contamination discharge laws, strategies, and new innovation practice for PHEV.

## **2.2 BEV TECHNOLOGICAL FACTORS**

### **2.2.1 ELECTRIC VEHICLE TYPES**

In recent times, different types of electric vehicles have been introduced such as: Battery Electric Vehicle, Hybrid Electric Vehicle, Plug-in Hybrid Electric Vehicle and Fuel Cell Electric Vehicle. All aspects of the EV innovation have acquired force to advance the EV economically on the grounds that this tech can affect the climate, power framework and related areas. It was uncovered that the current force framework will confront huge measures of unsteadiness in the current dissemination. However, with incredible administration and fruitful execution, innovative ideas will keep up both sides of the organic market. Moreover, this examination additionally centres on the information of EV structures, battery assets, electrical frameworks, procedures of re-energizing, enhancement way, the natural impacts, advancements in the field, and the potential guidelines of future alterations (Henschel et al., 2020). Result shows significant patterns and future advancements which were battery charging advances, better batteries, remote exchanges, and overhead force supply. Calculation showed that there will be sufficient exploration staying for the future investigation to comprehend. (Un-Noor et al., 2017).

### **2.2.2 BEV USAGE PATTERN**

Jie Fan (2018) researched the utilization designs of private EVs dependent on true information in China to comprehend attributes in detail. Information was gathered from 41 vehicles with 33041 trips and 4738 charging occasions (Huiming and Yuning, 2020). Boundaries of this investigation were charging start and end time, utilization, term, distance since last charge, introductory and last phase of charge, trip start and end time, first and only excursion time, day by day distance travelled, energy released in single point, energy utilization for 1000 km, explicit energy utilization, slowing down energy effectiveness, number of outings each day. Energy utilization was at first higher than information given, which can be because of utilization of the forced air system and the distinction among New European Driving Cycle (NEDC) and true driving conditions. Generative slowing down energy proficiency fluctuated from 25-45% for various EV. Moreover, this information can be appropriate to make a model for vehicle to network innovation model (Zhang et al., 2019).

Author characterized issues with second utilization of batteries to take out the cost of batteries in EV. Second utilization of batteries just highlights the expenses and evades the social and natural elements. This exploration paper characterizes the interdisciplinary methodology by zeroing in on EV innovation and recycled battery use in this plan of action. Consequences of this examination uncovers that recycled battery use was not maintainable practice in the EV section. In the outcomes, the author reveals that the EV market needs an imaginative plan of action for manageable ascent of innovation (Wulff et al., 2020). This plan of action has recycled the utilization of batteries to acquire incentive, respected creation – to acquire every one of the variables economically (Reinhardt et al., 2019).

Author created the driving pattern of EV clients by recording the information of speed on a second-by-second premise in Dublin city of Ireland. These driving cycles had the option to build up this present reality energy economy model by taking the level of street types, traffic, and other driving conditions (Yao et al., 2020). The Union Model of Driving Cycle was created by six ecological components examination by neural organizations. In various districts and urban communities, speed and speed increase rates will be changing which infers that these cycles may not be reasonable for configuration motivations behind EVs for certifiable applications. Driving cycles are fundamental for power train plan, battery range assessors and better information to the client. Dublin city's driving example will not be the same in all metropolitan and town territories (Brady and O'Mahoney et al., 2016).

## **2.3 BEV CHARGING INFRASTRUCTURE AND PRICE**

### **2.3.1 GLOBAL SCENARIO**

Dissected valuing technique and charging the board for accomplishing ideal interest in neighbourhood utilization of power, PV helped charging station and EV clients were taken in thought in the variables for examining through Stackelberg game re-enactments. In the PVCS structure, I thought about the network, energy data by means of Cell Cooling Coefficient (CCC), bidirectional AC/Dc converter and DC transport. Information was gathered by power markets and contributions of EV clients from the start step (Rahman et al., 2020). The outcomes showed that the Stackelberg model improved the working pay of PVC charging framework and diminish the EV use costs. Moreover, this model additionally showed ideal conditions for the PV nearby utilization (Tao et al., 2018).

### **2.3.2 IRELAND CHARGING INFRASTRUCTURE SCENARIO**

Pallonetto (2020) broke down the Irish charging framework to distinguish impact on driving the expansion of BEV. He utilized customer mindfulness rising as a key factor to check natural advantages from BEV. However, key discoveries from the exploration uncovered that absence of charging points in tech parks and shopping territories affected contrarily. This has brought about a delayed down of the BEV mass selection rate. This uncovered two viewpoints – end client and force framework point of view. In the end client, 1000 – 1400 h season of charging was in top workdays and in power framework point of view, high force use does not influence lattice network over-burden in top hours. Definitively, author recommended extension of the charging framework to improve selection pace of BEV in Ireland (Pallonetto et al., 2020).

Information was gathered from trip occasion factors, customer decision inclination, charging utilization example of client and timing (Ashkrof et al., 2020). The outcomes from this investigation will be additionally useful to create a charging point framework in distant spaces of Ireland. On premise of private and business responsibility, information was gathered from workday and end of the week occasions were investigated by ANOVA strategy to comprehend the conduct of EV clients. Besides, power utilization, charging time, distance, condition of charge was investigated in the examination to discover power networks in peak hours.

## **2.4 COST COMPARISON**

### **2.4.1 CHARGING PRICE COMPARISON**

Moon and Kim et al., (2017) have investigated the charging dispatch system to accomplish connections between methodologies of burden the executives and controlled deviation. Besides, the necessity of the power rate shows that heap vacillation rules had adequate administration plans (Zhang, M. and Fan, X., 2020). In order to maintain the **energy cost** and power loads, **an** ideal arrangement will be needed. In the outcome, load weight and positioning strategies in charging burdens, costs and speculation aversion were kept away because bending under burdens were not adequate to clarify unequivocally (Moon and Kim et al., 2017),

### **2.4.2 CHARGING PRICE COMPARISON IN IRELAND**

Peter Weldon (2018) thought about the ICEV and BEV depending on fuel cost, vehicle utilization, motivators, and battery substitution cost. In examination dependent on fuel cost, BEV are more productive than Internal Combustion Engine Vehicles (ICEV) in long- and medium-term use. According to the constant rise of fuel value, Weldon reasoned that EV will be less expensive than ICE in future with more prominent electric charging alternatives soon. Use of vehicles will have a high effect in cost examination if EV is used for more than 6 years compared to ICEV for the same 6 years (Ou et al., 2020).

## **2.5 SOCIO DEMOGRAPHIC FACTORS**

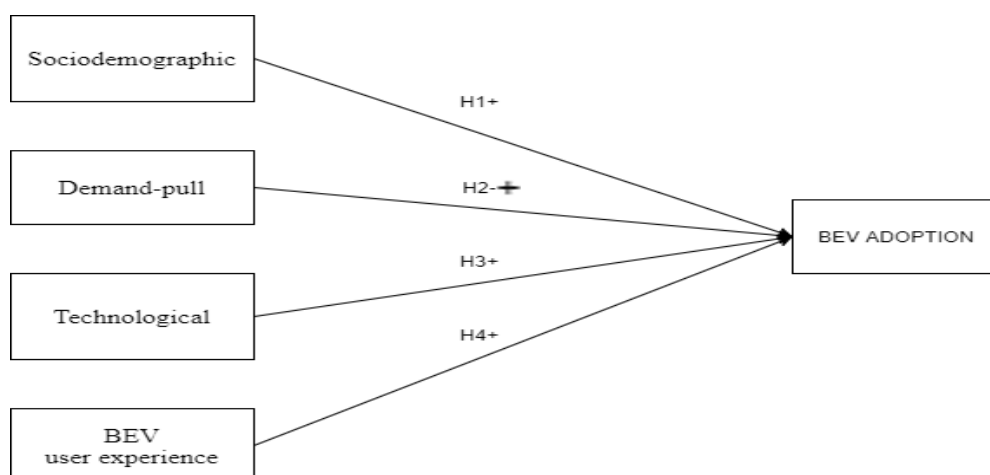
Allison Hui (2017) dissected the situation of EV shoppers in light of a legitimate concern for social change on the grounds that the buyers' class has expansive characters associated with social activity, relations, and change (Schmid et al., 2020). This examination investigates the consequences of these variables to comprehend essential things about the versatility arrangement of buyers conduct. It had concerns regarding two significant worries on the condition of location of the EV, the actions driving the fate of the EV and correlation with the ICEV and EV clients.

## 2.6 RESEARCH GAP

It has been found out that BEV research work in Ireland is in its developing stage. There is an exceptionally low number of articles on BEV. Past research work on the BEV worldwide market has given the comprehension of how the BEV selection process exists in different nations. There is no particular writing which has examined Irish BEV market. In any case, Eoin O'Neil has examined the merchant's view of the BEV. Sociodemographic factors, and mechanical factors are upheld in sections 3.4 and 3.5. Improvement of hypothesis is adjusted from past researchers (section 3.6). Definitively, research work on charging infrastructure or use design by different factual techniques has been done in recent years in different ways of investigation (Zhou et al., 2020).

## 2.7 THE RESEARCH MODEL & HYPOTHESIS SUMMARY

This exploration work, on examinations of the twenty components impacting the BEV appropriation in Ireland from four classes (Sociodemographic, Demand-pull, and Technological and BEV client experience). The exploration model with the speculation is represented in the Figure. Itemized clarification of the model and factors is clarified in the next part system.



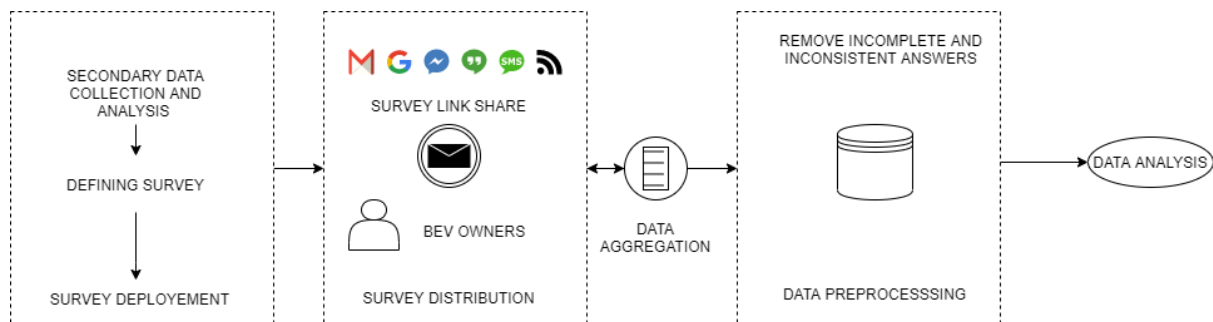
**Fig 2.1: Hypothesis summary**



## CHAPTER 3: METHODOLOGY

This section incorporates how the findings of the study will be further led by utilising distinctive factual techniques. Examination populace of BEV clients was chosen utilizing the authority information of Irish vehicle enrolment. Important information was gathered through the basis of online survey. Optional information of BEV was gathered from government CSO public information to comprehend and uphold the essential information assortment. Information investigation techniques for essential information give the perspective on strategies, conditions and required qualities for the outcomes. Finally, the ethic segment gives data with respect to the essential and optional information assortment of this exploration.

### 3.1 INTRODUCTION



**Fig.3.1: Flow diagram of the research strategy**

An online study poll was created utilizing the auxiliary information assets to incorporate all BEV factors. Online connection of Google structure was disseminated utilizing different web stages. For example, Facebook, LinkedIn, Reedit, E-mail, SMS, Feed, Hangout and Twitter (Shelly et al., 2020). The theoretical model is created depending on supporting speculations, writing, and optional information. Information was prepared before investigation in the SPSS apparatus by changing over to mathematical qualities. The secondary data has been based on the understanding of predominance of battery electric vehicles within the premises of Ireland along with its functionalities.

### 3.2 RESEARCH POPULATION AND SAMPLING

In terms of research methodology and analysis, the population is the whole group of individuals to understand. The interest of the population is the main part of research design because it dictates the scope of achieving objectives (Salkind et al., 2010).

#### 3.2.1 RESEARCH POPULATION

Registration information can be utilized for the populace in light of the fact that the regular interest can be found with perceived certainty. At a point when evaluation information is not providing full data of the focused-on populace.

As per (think business, 2021), there is an existence of 4500 BEV and PHEVs (plug-in hybrid electric vehicles) in the Island of Ireland. For understanding the BEV factors, just electric vehicle drivers have been considered in the exploration test. Inspecting configuration is clarified in the following area (SIMI Motors tats - the total online vehicle file for Ireland | Stats, 2020).

#### 3.2.2 SAMPLING METHOD

There are 4 territories in Ireland in which Leinster and Munster have 91% extent of electric vehicles in contrast with Connacht and Ulster. Homogeneous test has been incorporated for the determination of the prevalence of BEV cars within different sections of Ireland. Delineated irregular inspecting is taken in the testing cycle (Malhotra and Birks et al., 2007).

Sampling process (Malhotra (2006)) steps are as below.

D (Degree of precision) =  $p - \Pi = \pm 0.05$ , CL (Confidence level) = 95%,  $Z = 1.96$

Population standard deviation equation

$\frac{\sum (x_i - \mu)^2}{N}$	
--------------------------------	--

$$\sigma^2 = \frac{(263 - 1022)^2 + \dots + (98 - 1022)^2}{4}$$

$$\sigma = \sqrt{1261201.5} = \mathbf{1123}$$

$$\sigma_p(\text{Sample size}) = \frac{p -}{z} = \frac{D}{z} = \sqrt{\frac{(1 - )}{n}}$$

$$= 368.7936$$

$$\approx 370 \text{ (rounded to next highest integer)}$$

4 areas of Ireland have been chosen for segment qualities from optional information – SIMI (openly accessible). The analysis shows that examples are heterogeneous. To change over layers gathering to homogenous relative designation has been registered.

**Table 3.1: No. of EVs as per provinces**

Province (2019)	Used Imports (0 new imports)	New Registered	Total	Proportion (%)
Connacht	62	201	<b>263</b>	<b>7</b>
Leister	467	2445	<b>2912</b>	<b>71</b>
Munster	99	716	<b>815</b>	<b>20</b>
Ulster	16	82	<b>98</b>	<b>2</b>
<b>Total</b>	<b>644</b>	<b>3444</b>	<b>4088</b>	<b>100</b>
As per SIMI Jan 2019 to Jan 2020				

The above table presents the aggregated value of used imports and new registrations of the BEV vehicles in certain provinces. The expense work is corresponding to the table though changeability is conversely relative to the sample size.

For fixed 4 layers and absolute example size 370 to such an extent that it is relative to layer size.

$$n_i \propto N_i ,$$

$$\therefore n_i = N_i; \delta = \text{constant of proportionality.}$$

$$\sum_{i=1}^k n_i = \text{Or} = \left(\frac{n}{N}\right)$$

$$\therefore n_i = \left(\frac{n}{N}\right) N_i$$

[n = population of strata group, N = population,  $N_i$  = no. of sample,  $n_i$  = no. of strata group sample]

By applying the above equation to four different Ireland's provinces, the discrete value will be accomplished.

$$\text{Strata group 1 (Connacht)} = \frac{263}{4088} \times 370 = 23.80 \cong 24$$

$$\text{Strata group 2 (Leinster)} = \frac{2912}{4088} \times 370 = 263.56 \cong 264$$

$$\text{Strata group 3 (Munster)} = \frac{815}{4088} \times 370 = 73.76 \cong 74$$

$$\text{Strata group 4 (Ulster)} = \frac{98}{4088} \times 370 = 8.14 \cong 8$$

### 3.3 THEORY DEVELOPMENT

#### 3.3.1 MULTINOMIAL LOGIC (MNL)

MNL is utilised for the prediction of categorical placement within or the plausibility of categorical membership on a dependent variable in reliance to multiple independent variables. The MNL model is assessed utilizing most extreme probability strategies and yield incorporates the assessed utility boundaries, factual meaning of the utility boundaries, proportions of integrity of fit for the model as entire, versatility of decision concerning the different ascribes, and valuation of traits (Fan et al., 2020). The MNL model necessitates that

leader should have the option to differentiate the options which can be problematic for now and for the future. MNL is the beginning stage for experimental examinations of information prior to applying progressed discrete decision models (Louviere, Hensher and Swait, 2000).

According to RUT the probability of choosing an alternative is given by:

$$P_{in} = P(U_{in} \geq U_{jn}), \forall j \neq i$$

$$p(i,k) = \Pr U_i = \text{MAX}(U_i) \quad \text{Eq. 3.1}$$

Where:

$i=k$

$U_{in}$  = the utility level of the alternative.

$i$ = potential choice by individual  $n$  and  $C_n$  is the available choice set.

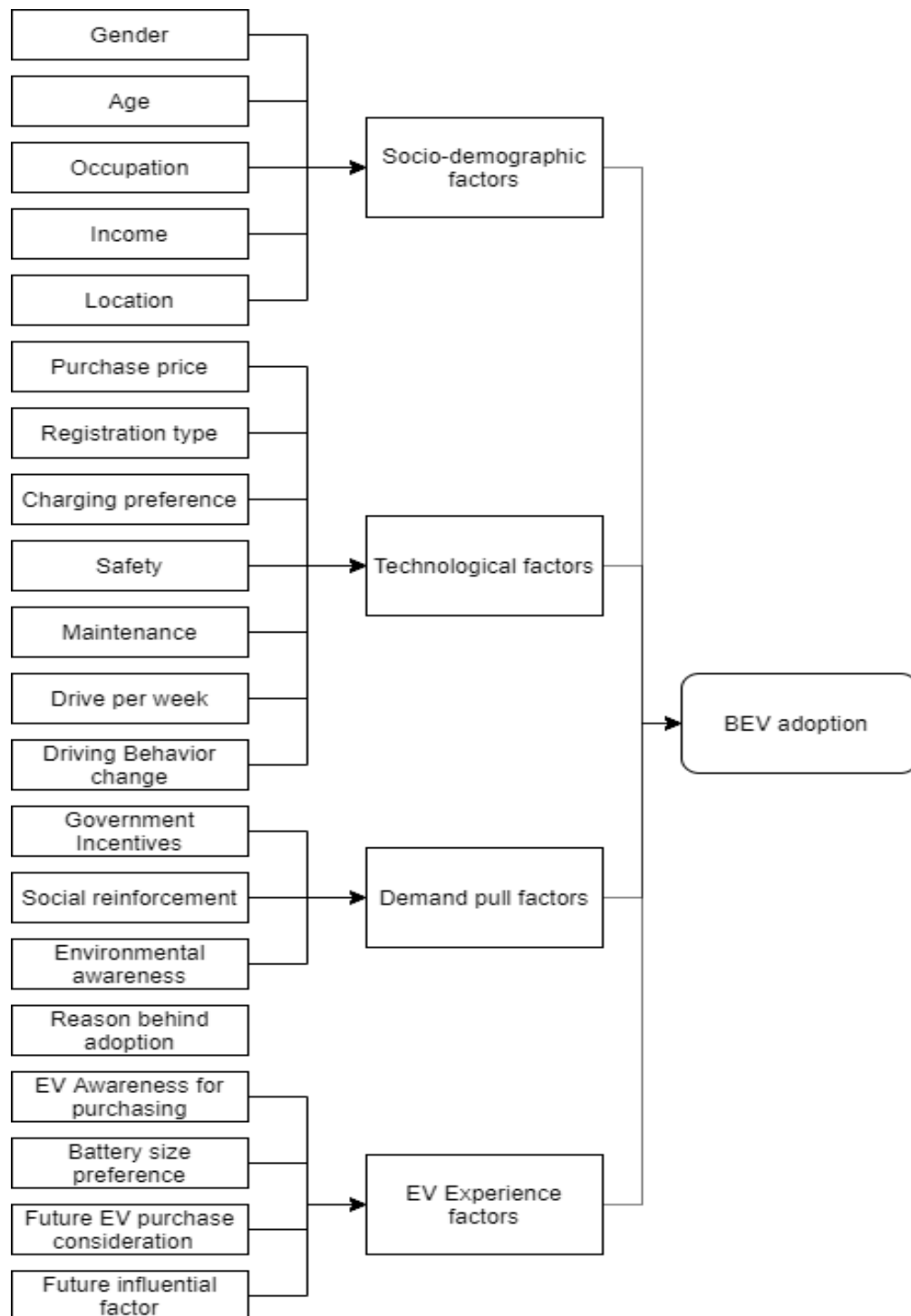
These utility capacities incorporate an efficient part and an irregular error, representing the unexplained components of decision conduct.

### 3.3.2 BEST-WORST DATA SCALING

The best-worst examination was created by Louviere and Woodworth (1990) as depicted in its first application (Finn and Louviere, 1992), the (B-W) scaling considers more extravagant data. For a bunch of three other options, B-W gives a total positioning, while, with four other options, a fractional positioning can be accomplished. Regardless of its nonstop use, the formal factual and estimation properties of B-W were exhibited distinctly in 2005 (Marley and Louviere et al., 2005). As demonstrated by a few on-going investigations in showcasing (Auger, Devinney, and Louviere, 2007; Cohen et al., 2009) and wellbeing financial aspects (Flynn, Louviere, Peters, and Coast, 2007),

By checking two alternatives (Best and Worst) rather than one choice, along these lines it is relied upon to give more noteworthy data content. All Best and Worst models are considered to meet the conditions for the weighted utility positioning models (Flynn and Marley et al., 2014).

### 3.4 RESEARCH MODEL



**Fig.3.2: Research Model**

(Source: As created by the Author)

### **3.4.1 SOCIO DEMOGRAPHIC FACTORS**

The socio-segment class incorporates gender, age, schooling, occupation, pay and locality. These factors are valuable for understanding the market to customers by methodologies of future patterns in purchaser interest as referenced in the online poll section. Gender and age give the current selection scope of clients. Education, occupation, and pay are connected with one another. For instance, if the client has finished designing instruction the likelihood of the designing occupation area is higher. Pay range gives the clients' scale factor. The provincial or metropolitan region has diverse populace which provides the data of higher and lower selection. This data does not contain a person's very own data like name, mobile number, address, or designation.

### **3.4.2 TECHNOLOGICAL FACTORS**

Past research study has included either driving reach or charging time factors in the mechanical class. In this examination, model name, buying date, battery size, enlistment type, charging inclination, drive each week/year, wellbeing, upkeep, change in driving conduct – all variables are considered to completely comprehend the affecting elements. The innovative factors were chosen according to the hypothesis and survey (Cui et al., 2020).

### **3.4.3 DEMAND-PULL FACTORS**

For advancing the BEV portion and pulling in the early adopter, the public authority give alleviation in the different tax assessment structure, awards for charging point and buying. Convincingly, to consider all these interests pull factors, this class incorporates Irish government motivators rating, ecological advantage rating and social support rating.

### **3.4.4 EV INFLUENCING ATTRIBUTES**

In order to comprehend the explanation for buying the BEV, multi-decision factors have been incorporated. Right off the bat, the mindfulness prior to buying factors are – brand, fabricate, model, battery utilization, range, charging alternatives, tax cuts, cost of exchanging e portability, environmental change, new experience – has been incorporated. Furthermore, impacting factors for the future selections additionally has multi-decision answers which remember upgrades for innovation, modest charging, more tax breaks, cost limits and natural advantage.

### 3.5 DATA COLLECTION

There are two sorts of information for directing the exploration. According to Encyclopaedia of Research Design First, essential information is initially gathered / separated by a specialist for research reasons. In light of the fact that the information is now gathered and prepared which saves time. Optional information should be gathered through required consent or government official information which is freely accessible. Auxiliary information has characterized the degree to continue in the exploration ('Secondary Data Source' et al., 2010).

#### 3.5.1 PRIMARY DATA COLLECTION

##### 3.5.1.1 VARIABLES SET 1

FACTORS	NO	VARIABLES	AVAILABLE OPTIONS
Socio-demographic variables	SD1	Age	Continuous scale by age groups
	SD2	Gender	Male
			Female
			Prefer not to say
Technological variables	TD1	Prefer to buy another BEV	Prefer to buy a new car
			Prefer to buy a used car
			Not sure
			Will not buy
	TD2	Charging preference in Rural and Urban	At home
			At Public charge points
			At Work
			All options



The reason for the reliant variable is to investigate Irish BEV client's inclination to the innovation of BEV according to their socio-segment factors. There are six unique inquiries for every factor (Alfaro-Algaba, M. and Ramirez, F.J., 2020). Socio-demographic variables along with gender were changed to mathematical worth according to the alternatives given in the study. For example, Male is allotted to '1', Female to '2', prefer not to say was '3'. Age is partitioned into the gatherings subsequent to understanding the statistics information of Irish Men and ladies by age range within 18-24, 25-34, 35-44, 45-54, 55-64, and 65-74. Subordinate mechanical factors are liking to purchase another BEV in future, purchasing and charging inclination. Numerous analysts have investigated this sort of ward factors to examine the impacts (Palinski, 2017; Locke et al., 2015; Adinolfi et al., 2015).

### 3.5.1.2 VARIABLES SET 2

The primary impact factors inspected were 15 components, which have appeared in the table. Each factor gauges according to choices accessible to each. Each factor's poll upholds the determination of the factors and choices accessible to each. This information was pre-processed for the investigation in SPSS to arrive at the prerequisite of hardware and staying away from mistakes.

FACTORS	NO	VARIABLES	AVAILABLE OPTIONS
Sociodemographic variables	SI1	Province	Connacht [ Galway, Leitrim, Mayo, Roscommon, and Sligo]
			Leinster [ Carlow, Dublin, Kildare, Kilkenny, Laois, Longford, Louth, Meath, Offaly, Westmeath, Wexford, and Wicklow]
			Munster [ Clare, Cork, Kerry, Limerick, Tipperary, and Waterford]
			Ulster [ Cavan, Donegal, and Monaghan]
	SI2	Education	Primary School
			Secondary School
			Bachelor's Degree

			Master's Degree or Higher
	SI3	Income	Range of lower than 18,000 – higher than 70,000
Demand-pull variables	DI1	Social reinforcement	The scale of 1(Minimum) to 5 (Maximum)
	DI2	Improvement of environment	The scale of 1(minimum) to 5 (Maximum)
	DI3	Irish Government benefits	The scale of 1(Minimum) to 5 (Maximum)
Technological variables	TI1	Purchase year	Numerical Entry
	TI2	Registration type	New Irish Registration
			New Imports
			Used Cars
	TI3	Safety	The scale of 1(minimum) to 5 (Maximum)
	TI4	Battery size	Numerical data entry in Kw/H
	TI5	Car Model	The model's name of cars
	TI6	Maintenance	Based on Yes, No or Maybe
	TI7	Improve the charging experience	Faster Charging
			More charge points availability
			1 card for charging
			Charging without cable

	TI8	Drive per week	Range of less than 100 Km/week to greater than 1000 Km/week
	TI9	Change in driving behaviour	Stopped using a car for a holiday trip
			No visit to fuel station
			Faster acceleration
			Efficient driving (low acceleration & speed)
			Divide long trips as per the driving range
			Prefer to do shorter trips because of the range
			No change

### 3.5.1.3 MULTICHOICE OPTIONS

In order to comprehend the BEV clients' disposition and conviction for BEV innovation in an explicit manner, multi-choice questions were chosen. To dissect the affecting variables based on the influential factors related to the acquisition of BEV, a multi-choice question was chosen. Alternatives accessible incorporate all assortments of answers which were adjusted from past writing and most recent updates in BEV ('Survey: Multiple-Choice Questions', 2017; Allen, 2017).

Affecting factors before the purchase of BEV	BEV brands & Models
	Battery size and driving range
	Charging options
	Tax benefits
	Cost of switching

	Environmental awareness
	Driving experience
	No research

Main reasons behind the adoption	Higher reliability
	Saving money
	Tax benefits
	Social influence
	Environment
	Employer benefits
	New technology adoption
	Better performance
	Better resale value
	Better look

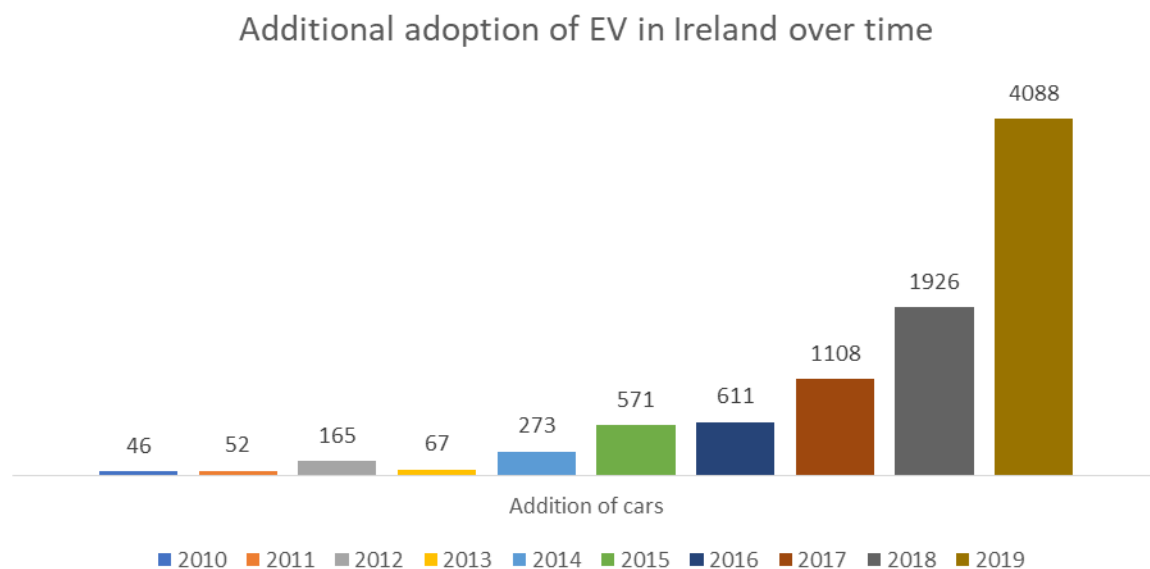
There will be more than one justification for receiving new innovation and to comprehend that the principal purposes for the reception are remembered for multichoice. Conservative, Environmental, Societal, Technological choices, and resale estimation of BEV is remembered for the multi-choice.

Future mass adoption	Improved battery range
	Cheap running cost
	More charge points for night charging
	Higher tax benefits
	Improved health from use

	Zero noise pollution
	Toll discounts
	More contribution to better environment

. In this exploration, BEV clients' perspective for mass selection in the fate of Irish BEV market is incorporated. This multi-choice gives the data of respondent's conviction and view for the most influencing factors for future.

### 3.5.2 INFORMATION DERIVED THROUGH SECONDARY SOURCES

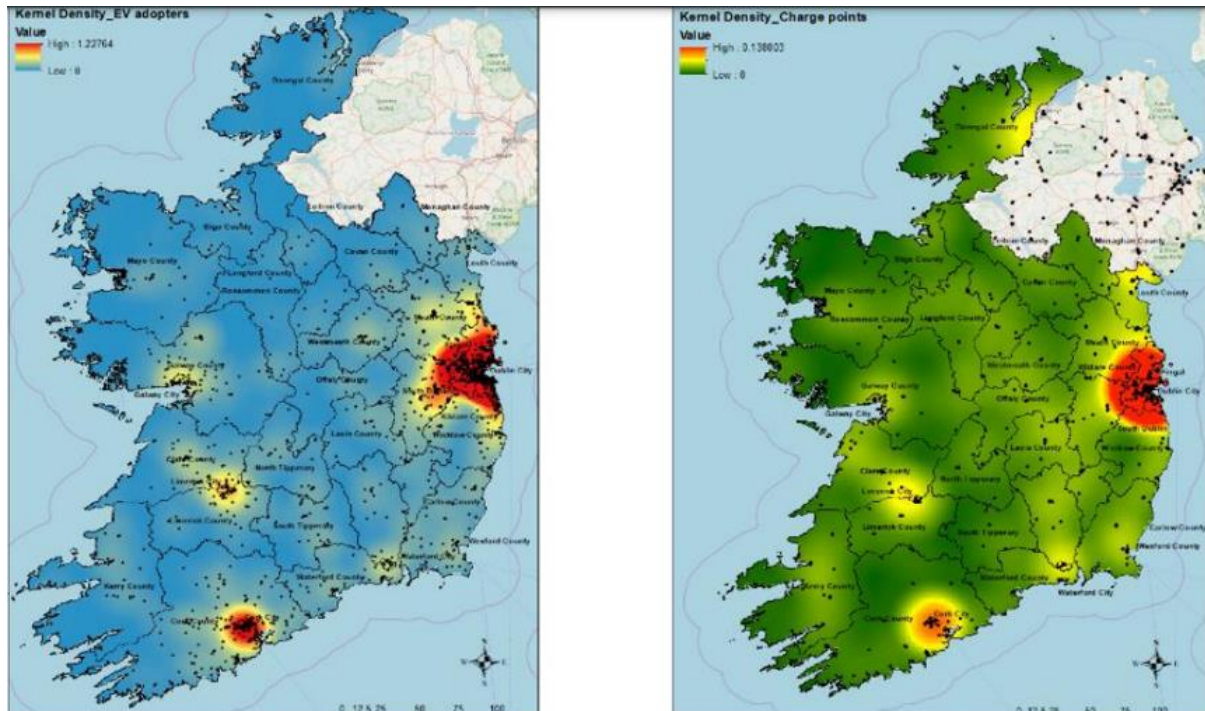


**Fig. 3.3: Additional adoptions of EVs in Ireland over time**

As demonstrated in the graph of new adopters of battery electric vehicle drivers, expansion in electric vehicles between the years 2010 to 2016 was low and after 2017, EV reception rate has progressed altogether. In Ireland, 70% BEV usage contributes towards 10% electric vehicles in use (SEAI, 2013). Nissan vehicle making organization is driving the EV market in Ireland which is evident from the diagram. Tesla Model S and Model 3 has an expanding number in reception more than BMW i3 in 2019 which shows that step by step decision of EV selection has been differing by refreshed value, battery size and charging time

and other new highlights (Kleiner et al., 2020). Besides, Hyundai's Kona and Ioniq are setting up their place in Ireland's market by offering low buying cost.

### 3.5.2.1 DENSITY ANALYSIS



**Fig.3.4: Density Analysis**

(Source: Density analysis of EV adopters & Charge points using ESB E-cars & SEAI data)

Location of the high density of electric vehicle adopters (marked in red colour) identifies the largest concentration of adopters. Dublin county and neighbouring border counties – Meath, Kildare and Wicklow have higher density whereas high to medium density are in Cork, Limerick, and Galway. Conclusively, for qualitative purposeful data collection, Dublin & Cork are the most populous regions in Ireland.

## 3.6 DATA ANALYSIS

### 3.6.1 COMPONENT FACTOR ANALYSIS

Factor examination explores the inside connection between numerous factors. By after-effects of factor examination, a variable can be assembled in the class or factors. This strategy cannot be utilized for speculation improvement since it just diminishes the discrete information

for additional measurable examination like relapse investigation. This strategy normally grouped into the exploratory factor examination and corroborative factor investigation.

The Kaiser-Meyer-Olkin measure shows the extent of difference in factors that may be brought about by fundamental components. High qualities (near 1.0) by and large show that factor examination might be helpful information. In the event that the worth is under 0.50, the aftereffects of the factor investigation most likely will not be valuable.

Bartlett's trial of sphericity tests the speculation which would demonstrate that factors are random and accordingly inadmissible for structure recognition. Little qualities (under 0.05) of the importance level show that factor examination might be helpful information (Exploratory Factor Analysis - an outline | Science Direct Topics et al., 2020).

### **3.6.2 RELIABILITY ANALYSIS**

In the information, noticed factors go together into a single scale. Dependability investigation decides the relationship of the variable to the scale. Socio-demographic, innovative, and technical factors have a variable on ostensible and scale premise. To decide the consistency of the information Cronbach's alpha has been additionally determined. Cronbach's alpha has a most extreme value 1. Typically, more prominent than the value 0.50 or bigger is dependable.

### **3.6.3 TWO WAY ANOVA**

This test aimed at the gathering of subjects, for example, innovative factors to socio-segment factors or experience components of BEV clients to mechanical variables. This test makes conclusions about the equality of the means of different features based on the variance between and within the groups. This correlation likewise can finish measurably, for example, T-test, a Chi-square, or One-way ANOVA. These outcome procedures gauge the impact of a solitary variable on thought about factors of consistent information. (Alin and Kurt, 2006; Ni, 2008).

Collaboration impact estimates the contrasts between the mean estimations of one variable when it does not have consistent worth across different factors. This impact assists with understanding the difference in reliant and autonomous factors. This impact can be clarified by two-way ANNOVA or investigation of change.

The ANOVA test has two discrete independent variables A and B where there are different values in each the variables, for example A1, A2, A3 while in B the variables would be B1, B2, B3, Bm. If the test has been performed for the independent variables (Ai, Bj) then the performance result would be cij. Therefore, all the cijos are independently related to each other and follow the normal distribution where c is the constant on the LHS. The normal distribution is a probability function that describes how the values of a variable are distributed. Therefore, the calculation related with adjusted MS:

$$MS(A) = \frac{SS(A)}{DF(A)}$$

$$MS(B) = \frac{SS(B)}{DF(B)}$$

$$MS(AB) = \frac{SS(AB)}{DF(AB)}$$

$$MS\ Error = \frac{SS\ Error}{DF\ Error}$$

Where, SSA is the sum of squares of deviations caused by variable A, SSB is the sum of squares of deviations by variables B and SSE is the sum of squares of error.

The specific significance level, error standards are observed from the result. That is connected to count the Degree of Freedom (DOF) in the finding as to how much results are accurate at the defined significant level. Degree of freedom values are the values which are free to vary in the final calculation.



### 3.6.4 ONE SAMPLE T – TEST

One sample T test is considered as the hypothesis test which is mainly used for identifying whether the unknown population mean is completely different from the specific value. This statically technique is often utilized in sociology research work. Mean contrast of tests has been analysed (Allen et al., 2017).

Mean average:

$$\bar{x} = \frac{\sum_{i=1}^n x_i}{n}$$

Standard deviation:

$$s = \sqrt{\frac{\sum_{i=1}^n (x_i - \bar{x})^2}{n - 1}}$$

Lower and upper confidence level:

$$\bar{x} \pm T_{df}^* \cdot SE_{\bar{x}}$$

Degree of freedom:

$$df = n - 1$$

### 3.7 ETHICS

In terms of conducting the Google form data collection process, the university rules have been followed strictly. There was no data like Name, address, Mobile number, or history gathered. All reactions were on an irregular ID number which was made by Google structure stage. The deliberate investment arrangement was the principal question. Respondents who concurred for deliberate cooperation had the option to fill the structure. In the survey data collection process, only topic related information has been incorporated. Notwithstanding, there was no video meet with respondents and just quantitative information was gathered.

## CHAPTER 4: RESEARCH RESULTS

### 4.1 INTRODUCTION

This section presents the results that have been gathered through the derived data post its evaluation. Part factor investigation and dependability examination presents the correlation between the variables. Two-way ANOVA and One example T-test strategies are utilized to demonstrate the findings.

### 4.2 DESCRIPTION OF RESULT

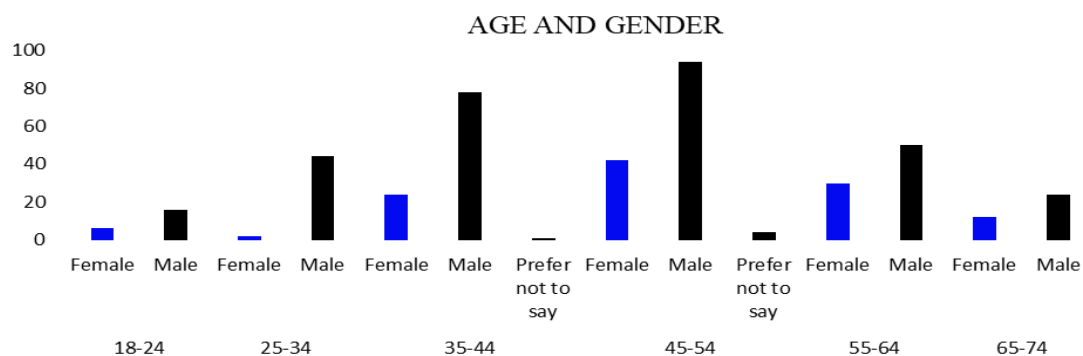
This segment incorporates a graphical introduction to comprehend the reaction of information. This part is separated according to four elements and each factor's variables.

#### 4.2.1 SOCIO-DEMOGRAPHIC VARIABLES

Socio-demographic factors give the data on age, gender, education, occupation, region, yearly pay – to comprehend the connection between factors among the characterized populace. All connected factors are utilised for the exploration work on the basis of enumeration information. Illustrative investigation shows the graphical portrayal of the gathered information.

##### 4.2.1.1 AGE AND GENDER

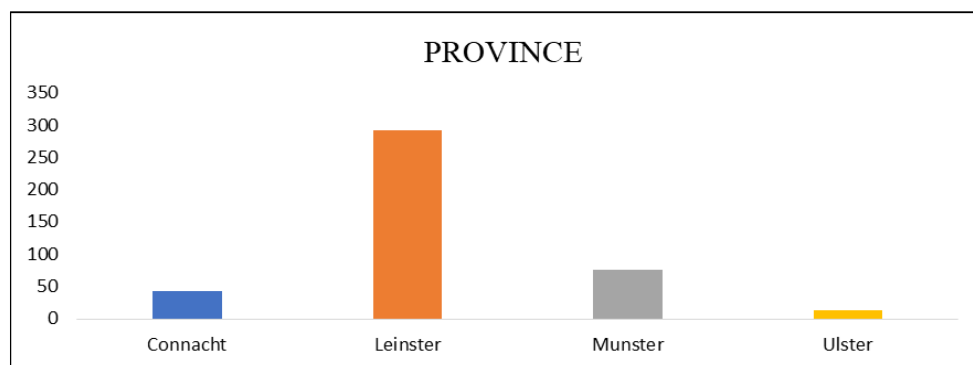
The response attest that the current proprietors of EVs are in homogenous gatherings. More than 66% of the current EV in Ireland is men. The EV proprietors' bit of the study was not restricted to a solitary member from an abode, and the idea of 'driver' was consequently deciphered by the clients, and as a rule, as confirmed by specific questions of the examination. There was no reaction more noteworthy than 75 years old and the base age was 18. Gender has three classifications of male, female and does not like to say for measurable information assortment.



**Fig.4.1: Age & Gender of respondents**

The group of 18-34 is recorded at most reduced EV clients. Irish EV user's age is profoundly in the middle of 35-54. Early period of drivers favours less EV than the higher age scope of more noteworthy than 35. EV proprietor's age is separated into the gathering of 35-54 and 55-74 for factual reason since significant respondents were in these classifications. This difference in preference due to age also indicates a relation with the income since BEVs are more expensive than ICE vehicles.

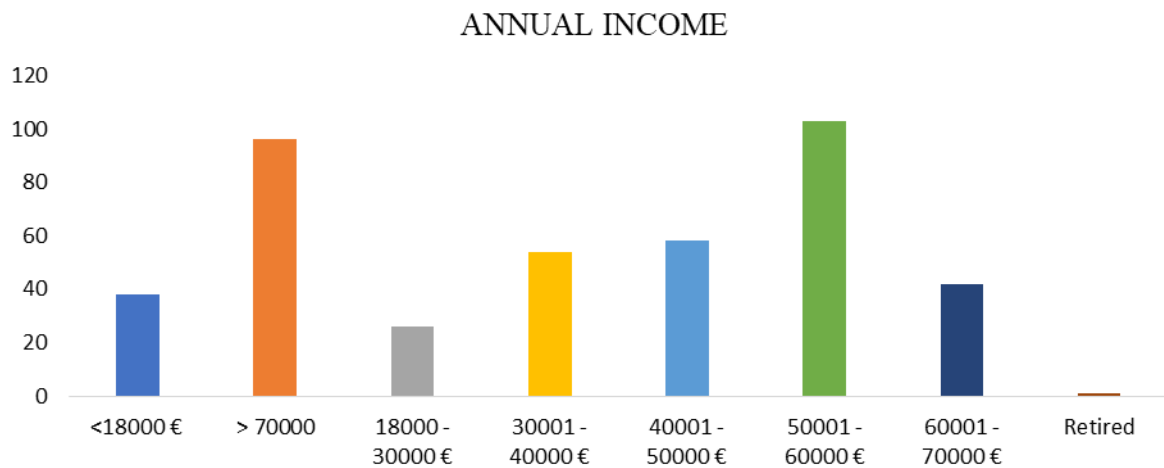
#### 4.2.1.2 PROVINCE



**Fig.4.2: Ireland Provinces**

Defined testing measures have been utilized in the examining cycle segment 3.5– Sampling. The above table presents four provinces highlighting the rate of adoption of BEV within the same. The four provinces include Munster, Leinster, Connacht, and Ulster among which Leinster records maximum adoption rate of electric vehicles. There are four areas in Ireland Connacht, Leinster, Munster, and Ulster. In Connacht - Galway, Leitrim, Mayo, Clare Island (Mayo), Roscommon, and Sligo regions are incorporated. In Leinster – Carlow, Dublin, Kildare, Kilkenny, Laois, Longford, Louth, Meath, Offaly, Westmeath, Wexford, and Wicklow are incorporated. In Munster – Clare, Cork, Kerry, Limerick, Tipperary, and Waterford territories are incorporated and in Ulster-Cavan, Donegal and Monaghan are incorporated. Complete number of EV in every region has appeared in area 3.4 – populace. To approve the layers gatherings and information approval, territory choice was remembered for the overview. As demonstrated in the chart, the state of layers bunches is fulfilled to accomplish homogenous gatherings in a heterogeneous populace.

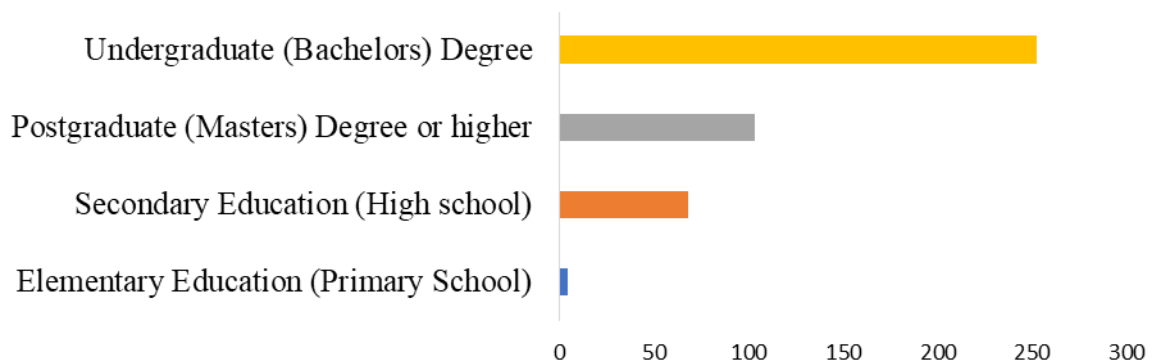
#### 4.2.1.3 ANNUAL INCOME



**Fig.4.3: Annual income**

Income and age are co-related with one another in Irish (Age - CSO - Central Statistics Office, 2020). In the EV drivers, yearly pay is more prominent than 40,000 € and up to resigned classification. There were a lower number of EV proprietors whose yearly pay lie under 18,000.

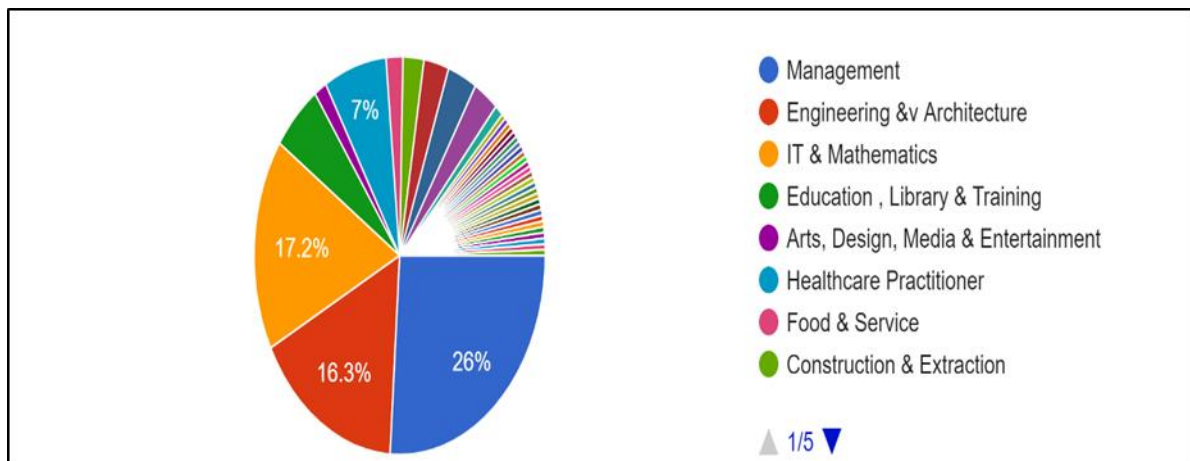
#### 4.2.1.4 EDUCATION



**Fig.4.4: Education**

As demonstrated in the bar diagram, the participants belonging to the undergraduate degree in comparison to other groups. Most noteworthy schooling capability in EV driver is an undergrad and postgraduate degree holder.

#### 4.2.1.5 OCCUPATION



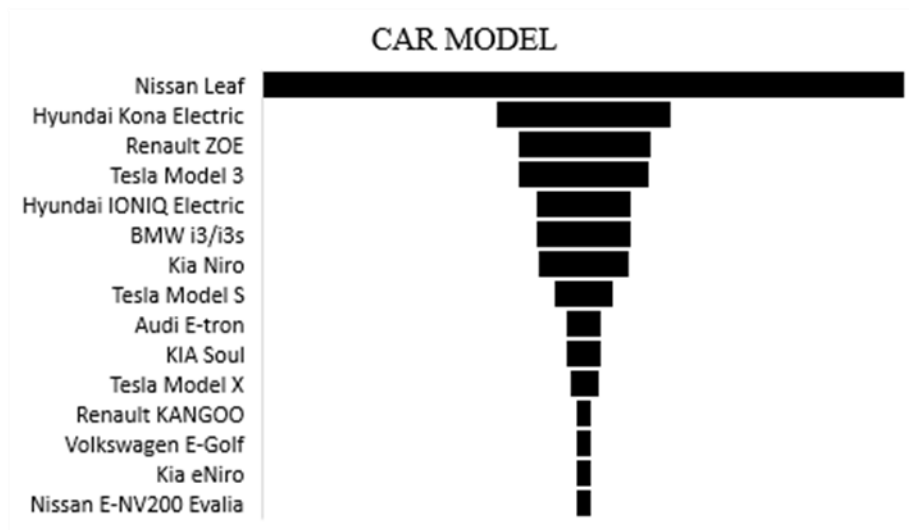
**Fig.4.5: Occupation**

Out of 32 classifications of occupation that have been reacted, just 9 classifications were characterized in the overview. More variety in the control of EV drivers appears in pie-graph. From the aforementioned figure, it is identified that 16.3% of respondents are in the engineering and architecture field. These show that there is no connection to occupation and EV drivers. One-fourth respondent has a place with the administration positions which are the most noteworthy among all classifications. Designing and IT Field is the second most displayed overview. These classes were limited into the principal areas for the factual investigation.

#### 4.2.2 TECHNOLOGICAL FACTORS

BEV innovation has been refreshing continually to acquire a piece of the pie. New highlights in the innovation are included new models and to comprehend the fundamental factors identified with utilization of EV. Vehicle model, battery size, running costs, security, charging inclination, enlistment type, normal driving and change in driving conduct – these factors are considered to exhibit the EV client's local area.

#### 4.2.2.1 CAR MODEL



**Fig.4.6: Car model**

There are 18 models of BEV accessible in Ireland according to Society of Irish Motor Industry (SIMI) information. All models are remembered for the study alternatives and thereby the specific selections are recorded. Renault and Volkswagen car organization have the most utilized models in the lower value range. EV prefers the range of 30,000-50,000 in buying of BEV according to the gathered information. Nissan Leaf is the most utilized model among all BEV. Hyundai, Tesla, Nissan, Kia, and BMW are the top auto rivals in Irish BEV market. SEAI gives award on buying the BEV according to the model's buying cost. The value scope of the models is appeared in the table.

**Table 4.1: Price of BEV**

(Source – All data has been taken from the official website of automobile maker)

<b>Car model</b>	<b>The minimum purchase price including SEAI grant</b>
Renault TWIZY, Renault New master, Renault ZOE, Volkswagen E-Golf, Renault KANGOO	<30,000
Nissan Leaf, Hyundai IONIQ Electric, BMW i3/i3s, Kia Niro, KIA Soul, Hyundai Kona Electric	30,000 – 40,000
Nissan E-NV200 Evalia, Tesla Model 3	40,000 – 50,000
Tesla Model S, Jaguar I-pace, Audi E-tron	>50,000

#### 4.2.2.2 REGISTRATION TYPE

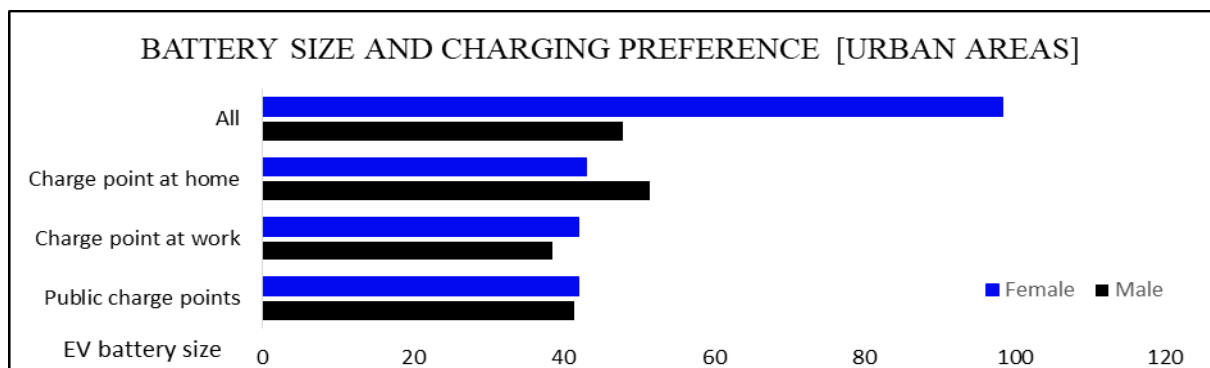


**Fig.4.7: Registration type**

Enlistments of the vehicle are separated into four classifications of new imports, new Irish, utilized Irish and utilized imports. Utilized Irish and imports have similarly lower price tag. Hardly any models, for example, Tesla Model X and Audi E-Tron were not accessible in buying year and because of that, they are imported. 33% of enrolment is on new Irish class in the reactions.

#### 4.2.2.3 CHARGING PREFERENCE

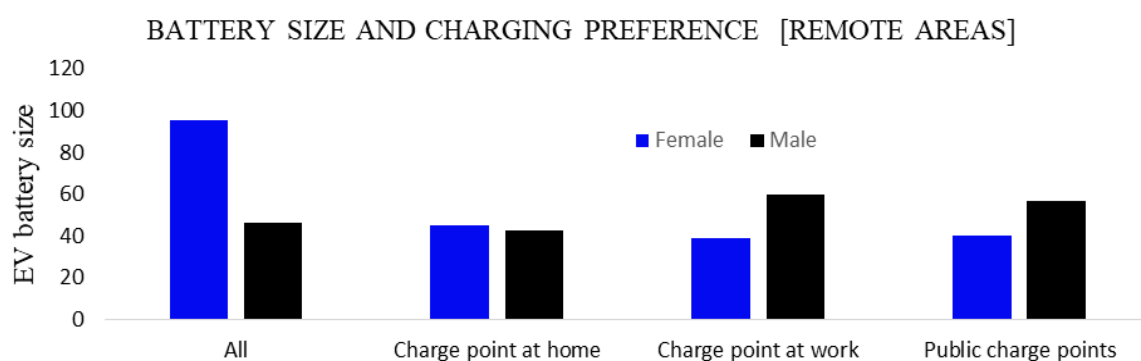
Charging inclination among BEV clients is ordered according to socio economics. Public chargers are profoundly accessible in metropolitan zones and less accessible in far off territories. To recognize the inclination in every, two choices are given in the reaction.



**Fig.4.8: Urban area charging preference**



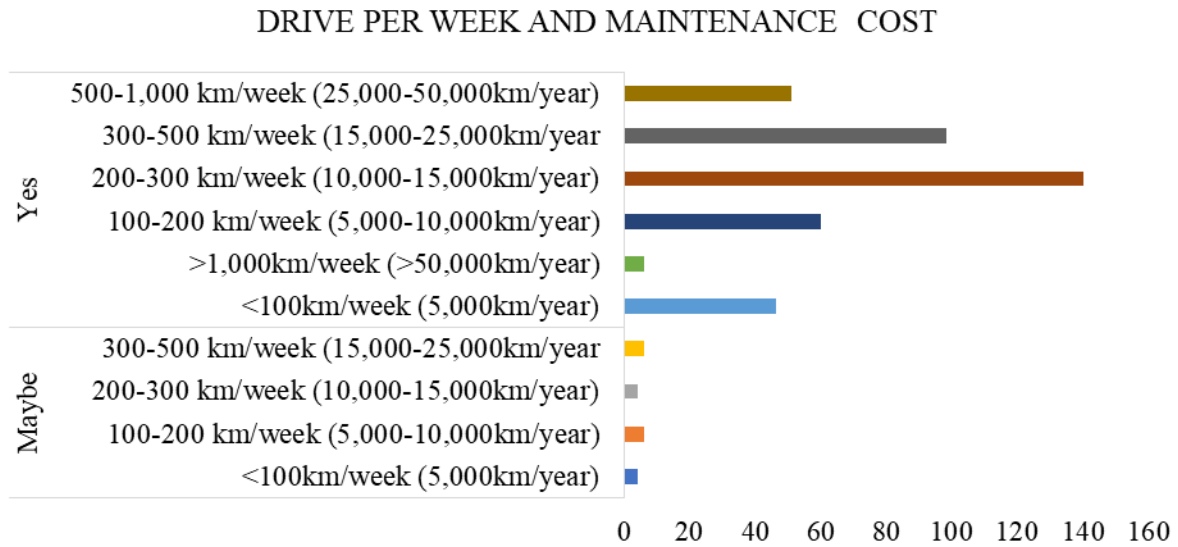
The figure below shows the charging inclination in the metropolitan regions according to the EV battery size and gender. All inclinations have a comparable reaction and there is no solid connection among the inclination. Male BEV users with normal battery size close by 40 Kw/h like to charge at home. Female BEV users have no particular inclination according to the study reactions. In the far-off regions, Male BEV clients whose battery size is higher like to charge at work and public chargers for the most part and female clients don't have a particular inclination in the charging. Because of less accessibility of home chargers in far off zones according to thickness investigation of BEV charge focuses, public chargers are profoundly utilized.



**Fig.4.9: Remote area charging preference**

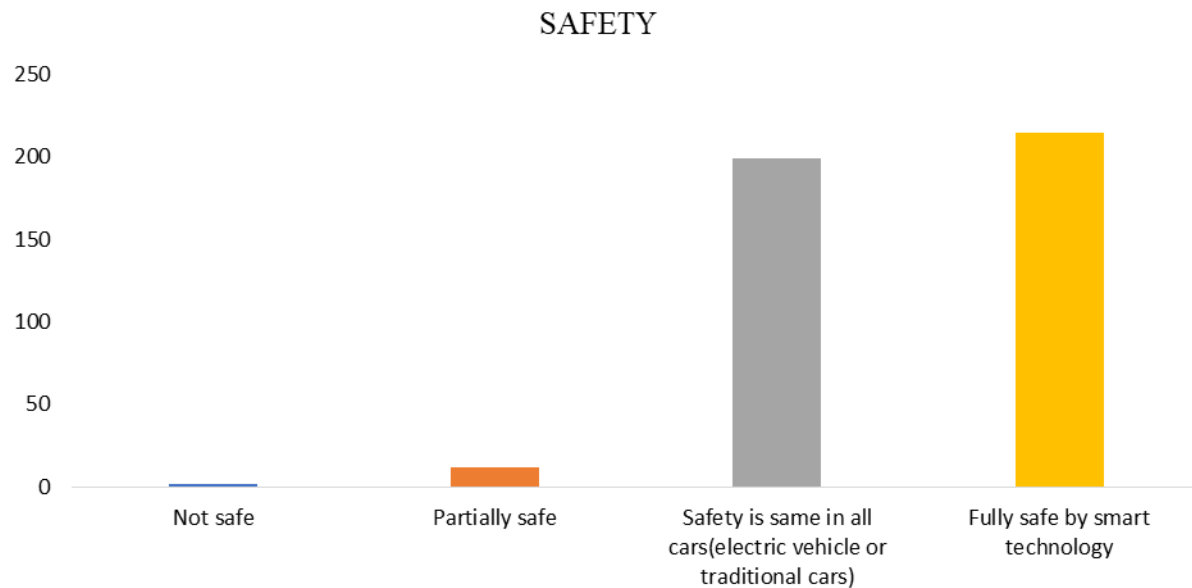
#### **4.2.2.4 AVERAGE DRIVING AND MAINTENANCE COST**

The maintenance cost of BEV is profoundly lower than customary vehicles in light of the fact that there is no mechanical wear and tear. In all reactions, no reaction accepts that support cost isn't lower than ICEV vehicles and just 5 % of respondents accept that there is a low upkeep cost. Normal driving of the BEV is partitioned into six classes – under 100, 100-200 Km, 200-300 Km, 300-500 Km, and 500-1000 Km. Among all significant reactions are in 200-500 Km range which shows yearly driving of 10,000 to 25,000 Km is driven by BEV clients on Irish streets. Some of BEV clients likewise really like to drive under 100 Km which shows that clients drive less on private vehicle.



**Fig.4.10: Drive per week and maintenance cost**

#### 4.2.2.5 SAFETY

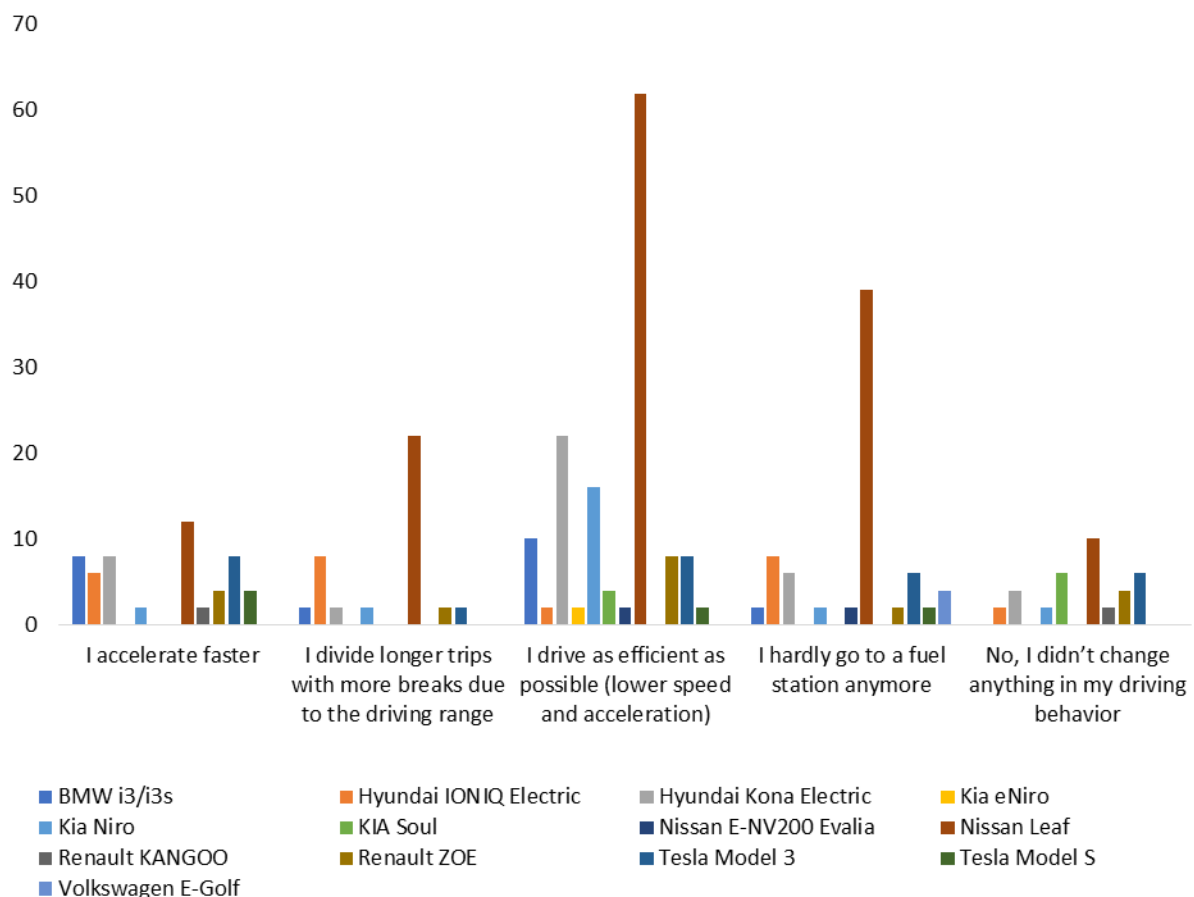


**Fig.4.11: Safety in BEV**

Security is quite possibly one of the main aspects of a vehicle. There are four classes remembered for the security –the perception related to safety in BEV is mixed. For some it is partially safe and for some it is fully safe. Apart from this some of the respondents perceive that BEV is not at all safe. Reactions show that BEV are more secure for driving. Besides, a greater part of clients feel that keen innovation makes more secure for driving BEV.

#### 4.2.2.6 DRIVING BEHAVIOR CHANGE

Exploration on BEV driving examples is moving around the world among scientists. New highlights and lower commotion of BEV cause the driver to feel diverse in driving. There are seven classifications in the adjustment in driving conduct. The main classification is clients who feel that they speed up quicker than customary vehicles. The subsequent classification is tied with driving reach. The third choice is tied in with driving proficiently by lower speed increase (Donkers et al., 2020). The fourth choice is about responsibility for ICEV - BEV clients who barely go to a fuel station. Fifth and sixth alternatives are tied in with utilizing BEV for longer excursions which has lower than 1% reactions. Significant five classes are appearing in the figure below. Most chosen alternative in it is driving proficiently to save the battery range for the outing. There was likewise a mixed reaction who feels that there are no adjustments in the driving conduct. Most chose choices are contrasted with the model of respondents with comprehend the change with BEV. Another noteworthy point to be noted is that in a single charge around 175kms can be driven except very few higher end vehicles like Tesla which allows the users to drive around 500kms.

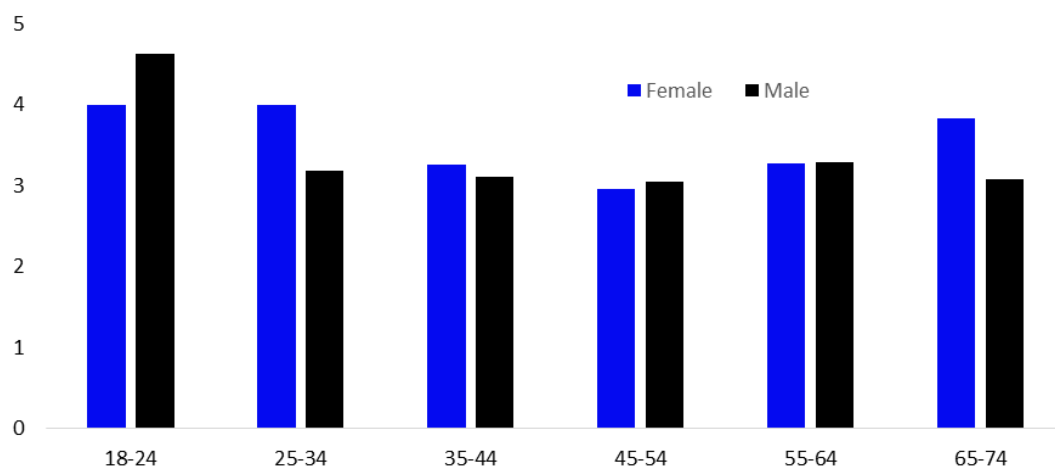


**Fig.4.12: Change in driving behaviour as per car model**

### 4.2.3 DEMAND PULL FACTORS

#### 4.2.3.1 GOVERNMENT INCENTIVES RATINGS

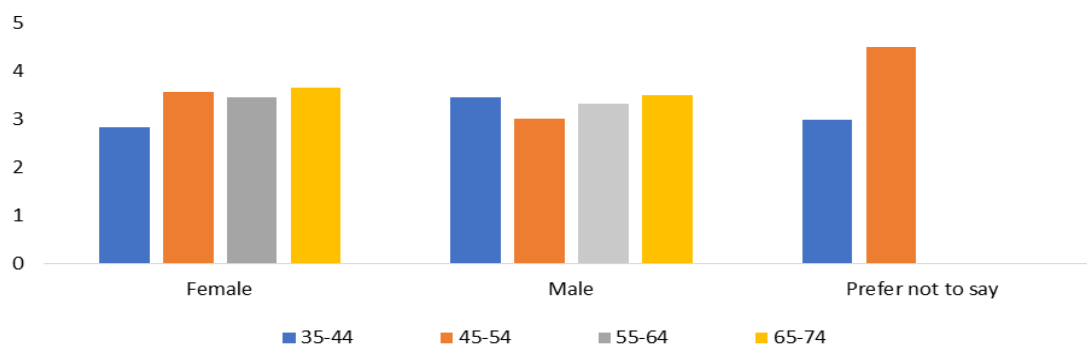
Mulling over all these advantages, response rate of the public authority impetus is given in the overview. 1 is considered as a base and 5 is considered as highest for the rating scale. Normal of 3 caters towards high response in the scale by BEV clients whose age is more than 35. The age scope of years 18-34 have a relatively lower number of BEV clients. However, they feel high due to fulfilment by government incentive schemes.



**Fig.4.13: Satisfaction of Irish government benefits**

#### 4.2.3.2 SOCIAL REINFORCEMENT

##### SOCIAL REINFORCEMENT

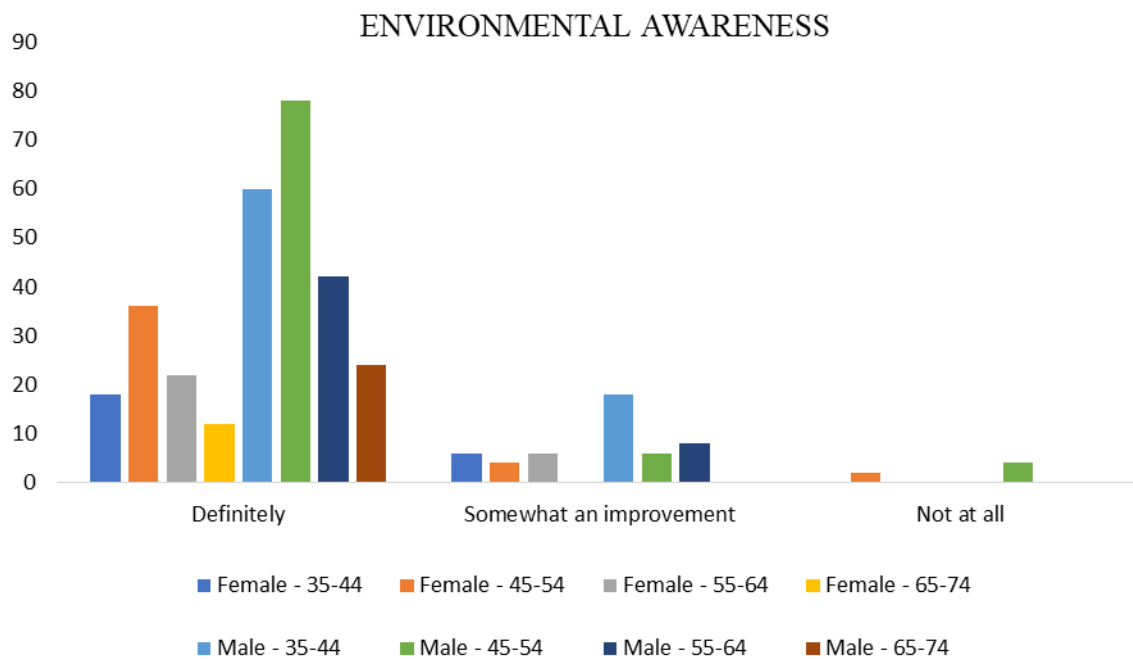


**Fig.4.14: Satisfaction of Social reinforcement**

On the base of positive and negative social reinforcement achieved by BEV use is included in the survey. These show the social benefits using BEV. Answer selection is on a scale basis of 1 to 5 in which 1 is considered as minimum and 5 is considered as maximum. Average ratings of 3 are collected from responses whose age is greater than 35. There is very less portion of respondents, who feel highly satisfied with the social reinforcement of BEV.

#### 4.2.3.3 ENVIRONMENTAL AWARENESS

To examine the ecological consciousness of BEV clients, BEV improves the climate factor is considered in the overview. Fewer than 3% of respondents feel that there is no advantage to the climate by BEV. Dominant part of reactions is recorded on which it shows that the BEV people group has a high attention to the climate.

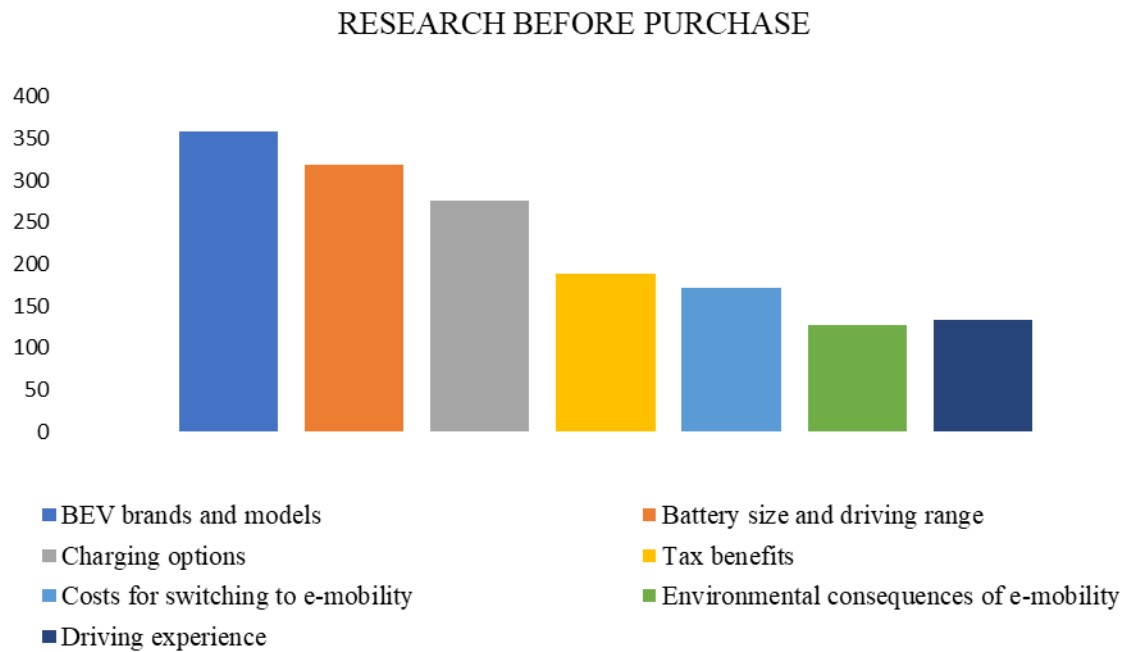


**Fig.4.15: Awareness of the environment**

## **4.2.4 INFLUENCING FACTORS**

### **4.2.4.1 RESEARCH BEFORE PURCHASING**

Examination before purchase is the main viewpoint behind the selection. To comprehend what sort of highlights and factors BEV adopters looked prior to buying, this multi-decision question is given in the overview information assortment. Conducting decision hypothesis expresses that there is no particular decision for the reception of new innovation in light of the fact that there are more factors behind explicit selection. Because of this explanation, multi-decision choices determination is given in the information assortment. There is a sum of 8 choices given in the multi-decision. First is about the price tag, prior to receiving BEV, clients looked for the vehicle brands and models. The study shows that brands and models have positive co-connection with the BEV appropriation. The subsequent choice is tied in with driving reach and battery size. The second most chosen decision of BEV adopters shows that driving reach and battery size influence exceptionally in purchase. Initial two decisions are clear in the determination since price tag and electric mileage are fundamental things of the BEV. At a point when individuals like to purchase ICEV, they never looked at the accessibility of fuel station (Sperling and Kurani, 1987), However, buyer of BEV explored about charging choices accessible to them. Charging alternative is third-most noteworthy chose decision of BEV adopters which shows that BEV appropriation and charging choices accessibility has positive co-connection. Just 50% of the reactions investigated tax reductions prior to buying. This shows that the Ireland government advantage fulfilment is lower among the adopters. The expenses related with changing to e portability, driving experience and natural outcomes decision is less chosen in every single decision alternative. ICEV and BEV driving experiences are unique. BEV does not have exhaust noise and mechanical vibrations which makes the driving experience distinctive (Hansen, Winther and Sorenson et al., 1995). To comprehend the impact of BEV drive insight, this decision is remembered for the choices. Nonetheless, fewer than 25% of BEV adopters chose this decision which shows that drive experience does not influence the buying expectations.

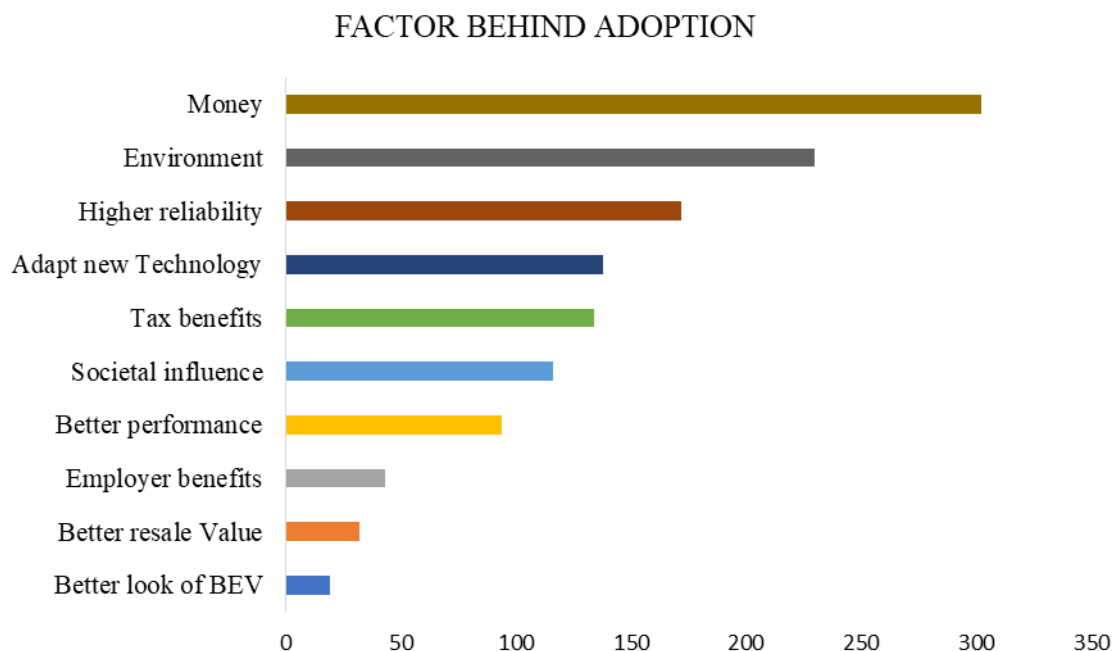


**Fig.4.16: Selections available before purchase**

#### **4.2.4.2 FACTORS BEHIND PURCHASE**

In the greater part of the exploration, creators attempted to discover the appropriation factor of non-BEV clients which makes blended outcomes. From the past writing and reports, 10 multi-decision choices are given in the inquiry. The primary alternative is to have higher unwavering quality. BEV has higher unwavering quality than ICEV and because of this, this decision is incorporated. Second is tied in with setting aside cash. Typically, Non-BEV drivers get contrarily influenced by the higher acquisition of BEV. However, BEV saves cost (in long haul situation), while travelling a long distance because of its low-cost maintenance and running expenses. This factor is incorporated to comprehend on what level this variable influences the buying factors. The third choice is tied in with accomplishing more tax breaks from BEV than some other vehicle. The fourth alternative is a cultural impact for understanding the size of this factor among any remaining decisions. BEV saves the climate by zero-emission and because of this explanation; to save the climate choice is remembered for the overview. Numerous businesses are discarding offering stopping and charging to BEV in Ireland which draws in workers to utilize BEV (Huiming, D. and Yuning, W., 2020). To comprehend the impact of this office, the business benefits decision is remembered for the choices. BEV innovation spread and its thought is one of the significant viewpoints. To dissect the impact of tech reception, this choice to receive new innovation is remembered for the multi-decision

choice. BEV speed increase and perfection is superior to ICEV which causes the driver to feel better exhibition. The choice to feel better execution is remembered for the multi-decision. BEV looks are not the same as customary vehicles. They are more streamlined or trendier. To investigate this impact on buying goals, this alternative is incorporated. In conclusion, BEV request is rising universally which implies the resale worth will be relatively higher than customary vehicles. Among all decisions, 75% of respondents chose setting aside cash behind the selection of BEV. This shows that BEV has greater expense saving in running and support in the sustainability. The second most chosen decision is saving the climate. Ecological mindfulness influences the adopters for buying in light of zero discharges and practical use. BEV has higher unwavering quality than ICEV as far as experience and trust in the new innovation. Adopters feel that BEV has higher unwavering quality since it is a third most chose decision. Demand pull factors modest affect the buying expectations since tax reductions and cultural impact is chosen by low respondents in contrast with different factors. Under 10% of respondents considered better resale worth and look of BEV which shows that they do not think about these elements behind the reception. The graph shows, apart from money and environment, high reliability and adapting to new technology plays a vital role in convincing people to buy EVs, so proper branding strategy must be developed.

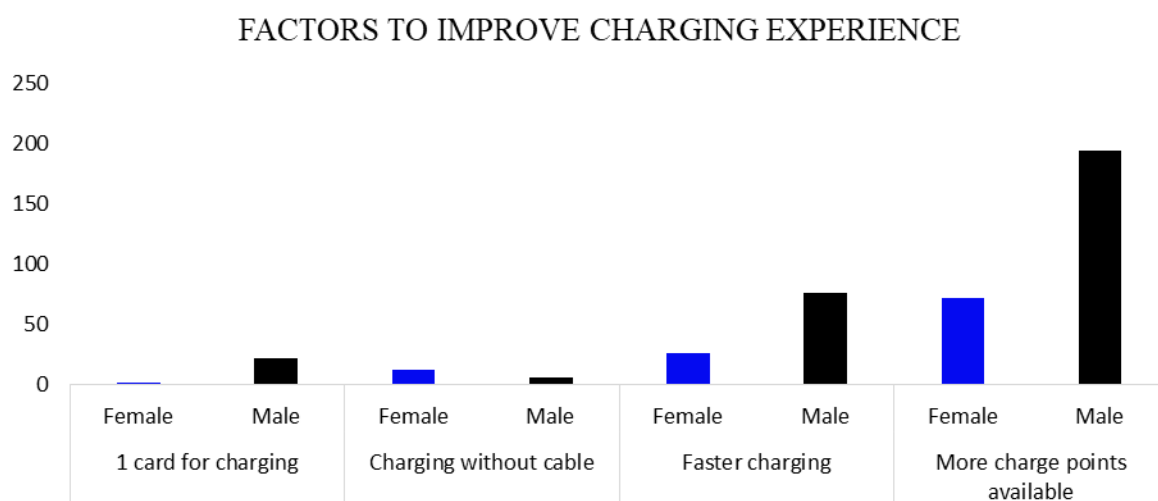


**Fig.4.17: Selections of factors for adoption**



#### 4.2.4.3 IMPROVING CHARGING EXPERIENCE

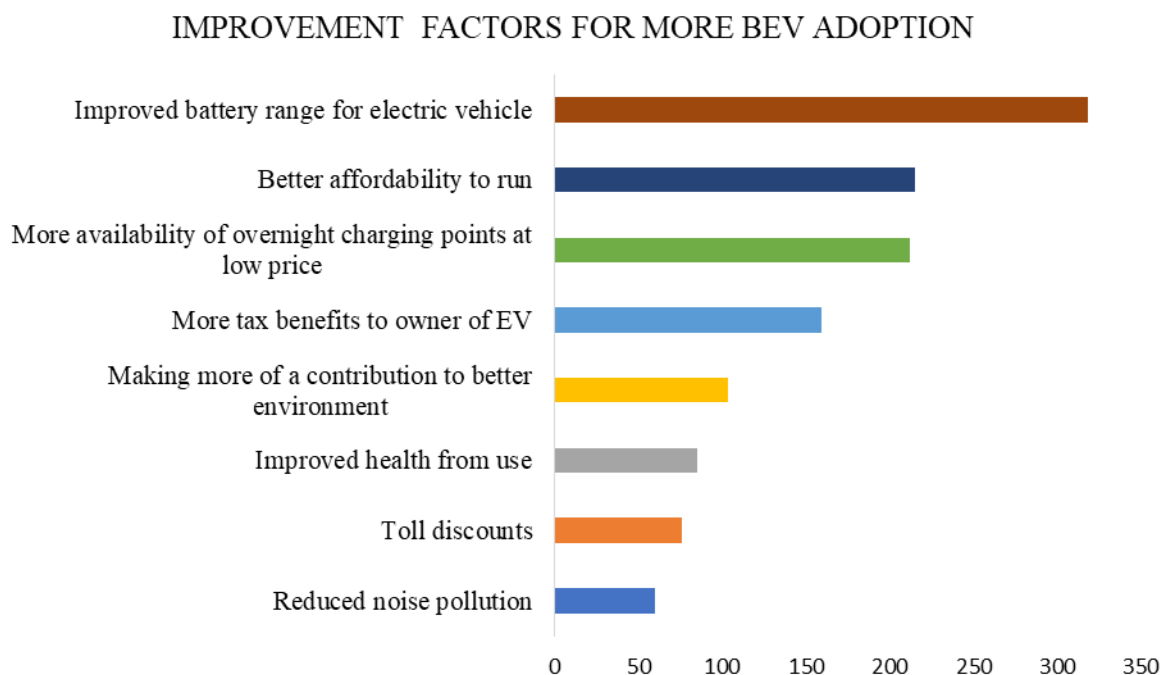
Charging experience influences the practicality of the BEV clients and it will influence what is to come for adopters' aims. To comprehend Ireland's charging upgrades, four choices are remembered for the study. These days, there are numerous suppliers for charging, which at times befuddle the clients about the rate and time. A single card for charging will assist all the information of the clients to dissect the charging conduct. Charging without a link is moving in the new innovation like PC or TV. BEV charging without a link makes it simpler for the charging. Quicker charging focuses are not generally accessible to the clients in Ireland which inculcates additional time. Finally, more charge focuses accessibility is consistently vital for the upgrades. These elements are considered in the review to comprehend which factor is generally significant for the enhancements in charging experience. There are 25 charging points every 100 Kms on highway and in excess of  $1200/25=48$  charging points which are accessible in Ireland. According to the study, most noteworthy reactions are gathered for additional charging focuses available by the clients of BEV across Ireland. This shows that there is, yet a lower number of charging points accessible. For better charging experience later on, more charge points will improve the utilization of BEV. A quicker charging choice is chosen by under 25% of respondents in the study. One card for charging a lot without link is chosen by under 10% of respondents. This shows that, right now there are no requirements for cutting edge highlights for charging on account of the low number of charging choices accessible.



**Fig.4.18: Selections of factors for improving the charging experience**

#### 4.2.4.4 IMPROVEMENT FACTORS OF ADOPTION

Demand- pull and innovative variables are considered in the improvement factors for more BEV selection by the BEV adopters. There are 8 decisions to be considered in the multi-decision choice of progress factors for mass appropriation later on. Battery range has been improving since the BEV is moving. More scope of BEV makes it helpful for the client. The second accessible decision is better reasonableness to run. Upkeep and running expenses are lower in the BEV however buy cost is relatively higher. On the off chance that the running expense of BEV gets lower than it will be reasonable to the clients after buy. Third accessible is greater availability of overnight charge focuses on a lower cost. Charging points availability in Ireland is higher than fast charging. Evening power use is less expensive than daytime use and helpful for BEV clients to charge in the evening time to utilize BEV in the everyday practice (Wulff et al., 2020).



**Fig.4.19: Improvement factors for future mass adoption**

Fourth are more tax reductions by utilizing BEV. At present, Irish government is providing tax reductions to BEV adopters which is not influencing people for the buying aims. If the government provides higher reliefs in the tax assessment; then it might influence the improvement to the BEV number improvement. Fifth and sixth are about improved wellbeing from use and toll decision. To decide these elements impact for future improvement thought, the two factors are considered in the multi-decision. Seventh is more cost limits while driving

BEV (Erick et al., 2020). Current cost charge limits are half of the public roadways which is one of the advantages of government motivating forces. In the event that more cost rebate is given to the BEV adopters, then it tends to be gainful for future selection. Climate mindfulness is one of the significant commitment factors behind the selection of BEV from the non-BEV adopters. Improved battery range for long excursions is the most affected factor for the future appropriation for BEV adopter. BEV adopters who drive BEV more than 200km each week feels that if BEV has a preferable driving reach over it will be the most influencing factor for the mass future selection. Better affordability to run is the second most chosen decision in the multi-decision. Over half of respondents chose this alternative. In the event that the accessibility of overnight chargers at a lower cost can increment than it very well may be influenced decidedly for future selection. With a determination of over half of respondents in this decision shows that it is one of the significant elements. Government motivating forces to the Irish BEV adopters are not influencing emphatically in light of the fact that in the normal scale premise rating is 3.2 out of 5. For a future affecting component, half of the respondents feel that more tax breaks can assist with adjusting the new innovation for future selection. Diminished clamour contamination, cost limits and wellbeing enhancements are not corresponded with the impact of future appropriation of BEV. These decisions are chosen less than 20% of respondents as it were.

#### **4.3 COMPONENT FACTOR ANALYSIS**

The response of the members was stored in the Statistical Package for Social Sciences (SPSS). The SPSS instrument is generally utilized for logical and study research projects as indicated by the [www.spss.com](http://www.spss.com). This bundle can stack and investigate basic information. The presentation of graphs is to recognize the mean and standard deviation of the frequencies of information. To accomplish the precision of information and distinguish the reaction rate, elucidating examination is utilized for all variables.

### 4.3.1 SOCIO-DEMOGRAPHIC VARIABLES

The designation of reactions is part according to the age, sex, territory of Ireland, instruction and yearly pay as introduced in table 4.2. This table guarantees that there is no invalid instance of reaction in the information examination.

**Table 4.2: Descriptive Statistics of socio-demographic questions**

VARIABLE	Mean	Std. Deviation
AGE	2.70	1.026
GENDER	1.28	.448
PROVINCE	2.13	.615
EDUCATION	3.07	.657
ANNUAL INCOME	1.94	.714

**Table 4.3: Correlation matrix of socio-demographic variables**

VARIABLE	AGE	ANNUAL INCOME	GENDER	EDUCATION
AGE	1			
ANNUAL INCOME	.175**	1		
GENDER	.164**	-.120*	1	
EDUCATION	-0.008	.213**	0.008	1

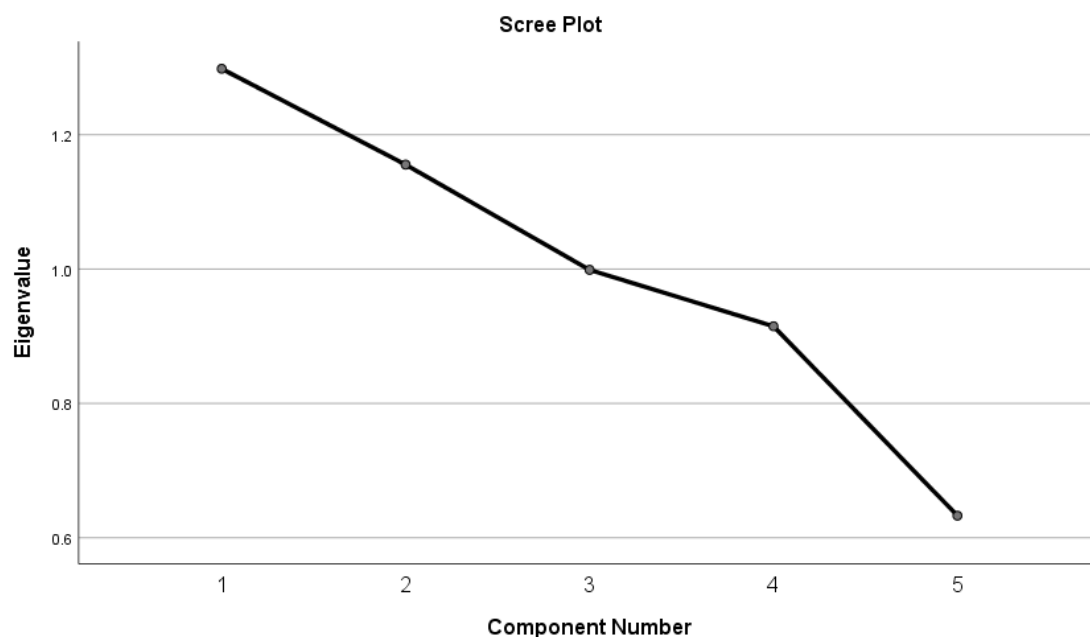
In table 4.3, correlation matrix, it is comparing each factor to another factor but when the same factor on row and corresponding column arrives, 1 is mentioned thereby signifying highest correlation with itself. When each factor is repeated on row and column, it gets the same result, so the blank spaces are repeated. Correlation matrix of age, annual income, gender, and education have appeared in the above table. The asterisk indicates the correlation value

amongst the variables. Any remaining socio-segment factors are essentially corresponded with one another. All connections with one another have not been clarified completely on the grounds that it does not have more noteworthy than 0.20 worth which shows lower stacking on a similar factor.

**Table 4.4: KMO and Bartlett's Test of socio-demographic variables**

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.633
Bartlett's Test of Sphericity	Approx. Chi-Square	58.732
	Df	10
	Sig.	.000

KMO and Bartlett's test guarantee the supposition of the test. KMO testing value is .633 which shows adequate outcomes for one another. Critical (below 0.005) is 0 which shows that the relationship framework.



**Fig.4.20: Scree plot of Socio-demographic variables**

The Scree Plot shows the underlying Eigenvalues. Eigen values are scalars used to transform or stretch an Eigenvector. Eigenvalues and Eigenvectors are used in linear differential equations where to find a rate of change or when to maintain a relationship between

two variables. The plot shows that there is no huge number of drops off after the initial two factors. Qualities lie between 1.2 to 0.6 which shows that absolute difference table will assist with deciding complete eigenvalue and combined (%). As demonstrated in the chart, values persistently diminished after the initial two-segment which upholds the two-segment arrangement. The aforementioned graph also states about the decreasing trend of socio demographic variables.

**Table 4.5: Total Variance Explained**

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	1.298	25.963	25.963	1.298	25.963	25.963	1.290	25.801	25.801
2	1.155	23.109	49.071	1.155	23.109	49.071	1.164	23.270	49.071
3	.999	19.975	69.047						
4	.915	18.296	87.343						
5	.633	12.657	100.000						

Extraction Method: Principal Component Analysis.

Total variance table clarifies the part is split between 5 potential variables. A few things worth of every change is clarified altogether. Initial two-segment has an esteem higher than 1 which acts as a determinant for standard value. Total (%) of part 2 is 49 % which shows that portion of the fluctuation represents the initial two variables. Extraction Sums of Squared Loadings and Rotation Sums of Squared Loadings has a similar incentive for the first segment.

**Table 4.6: Component Matrix**

VARIABLE	Component	
	1	2
ANNUAL INCOME	.787	-.197
EDUCATION	.574	-.258
PROVINCE	.299	.047
GENDER	-.045	.799
AGE	.507	.640
Extraction Method: Principal Component Analysis.		
a. 2 components extracted.		

**Table 4.7: Rotated Component Matrix**

VARIABLE	Component	
	1	2
ANNUAL INCOME	.812	-.004
EDUCATION	.619	-.114
PROVINCE	.280	.117

GENDER	-.233	.765
AGE	.340	.743
Extraction Method: Principal Component Analysis; Rotation Method: Varimax with Kaiser Normalization; a. Rotation converged in 3 iterations.		

**Table 4.8: Component Loadings for the Rotated Components**

ITEM	Component loading	
	1	2
ANNUAL INCOME	.812	-.004
EDUCATION	.619	-.114
AGE	.340	.743
Eigenvalues	1.3	1.2
% of Variance	49	24

Principal component investigation with Varimax Kaiser Normalization was directed to get to five Socio-segment factors. Two segments were turned, in light of eigenvalues more than 1 rule and the scree plot. After evaluation, the principal part represented 49% of the fluctuation presents the components and segment loadings for the turning parts, with loadings under .30 excluded to improve clearness.



#### 4.3.2 DEMAND PULL FACTORS

**Table 4.9: Descriptive Statistics of Demand-pull factors**

VARIABLE	Mean	Std. Deviation	N
IRISH GOVERNMENT INCENTIVES/BENEFITS	3.22	.891	402
SOCIAL REINFORCEMENT	3.40	.942	402
IMPROVE THE ENVIRONMENT	1.26	.536	402

Demand- pull factors are separated into three classes and table 4.9 (Descriptive) guarantees that there is no mistake in the reaction information. Mean and standard deviation of the Irish government impetuses and social support is higher than improvement to the climate. Importantly because of the improvement to the climate is four scales based and the other two are the 1(As low) to 5(As high).

**Table 4.10: Correlations Matrix of Demand-pull factors**

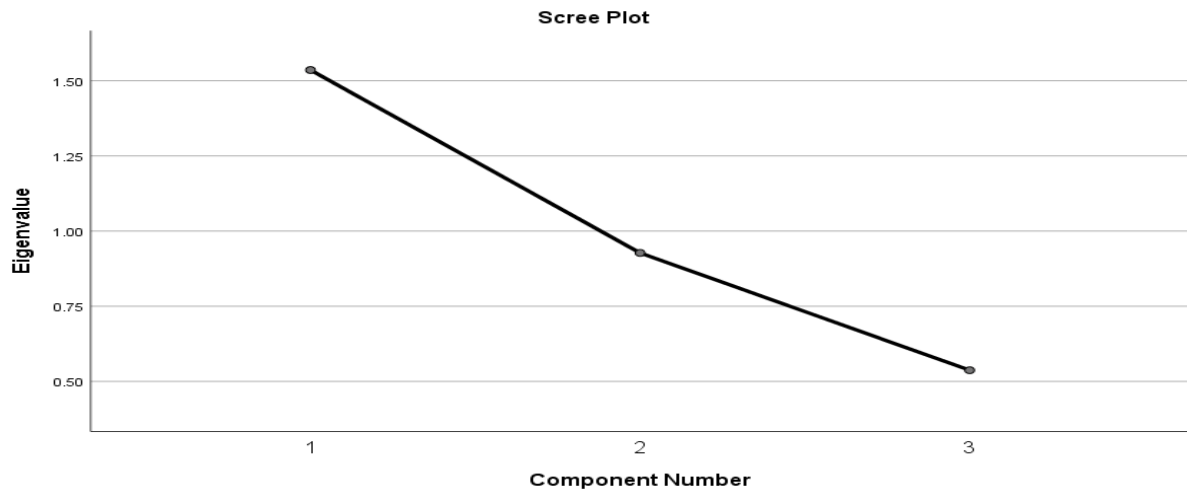
VARIABLE	Irish Government benefits	social reinforcement	improve the environment
Irish Government benefits	1		
social reinforcement	.450**	1	
improve the environment	-.201**	-.099*	1

Co-connection framework shows relations between Irish government impetuses/benefits, social support, improvement to the climate in light of BEV. This connection has not been finished paperwork for ecological enhancements and social support. Irish government advantages and social support has a solid positive relationship at 95% certainty level. Nonetheless, Irish government motivations and ecological upgrades have a negative relationship.

**Table 4.11: KMO and Bartlett's Test**

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.728
Bartlett's Test of Sphericity	Approx. Chi-Square	107.017
	Df	3
	Sig.	.000

Kaiser-Meyer-Olkin (KMO) measure of Sampling Adequacy is higher than 0.5 which shows that this outcome has solid match. Importance level at 0 shows that the KMO test is critical for the part framework.



**Fig.4.21: Scree plot of demand-pull factors**

This line diagram shows that after the main variable distinction between eigenvalues decline and those qualities are close to 0.50 which shows that it did not uphold two-segment arrangement. Unwavering quality examination of scale-based factor is clarified in the following segment.

**Table 4.12: Total Variance Explained**

COMPO NENT	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	1.536	51.186	51.186	1.536	51.186	51.186
2	.927	30.910	82.096			
3	.537	17.904	100.000			
Extraction Method: Principal Component Analysis.						

**Table 4.13: Component Matrix**

	Component 1
--	-------------

Irish Government benefits	.837
social reinforcement	.789
electric cars improve the environment	-.461
Extraction Method: Principal Component Analysis.	
A.1 component extracted.	

The prime segment framework shows that Irish government motivators have solid connections in contrast with social support. In absolute difference, the first segment has more noteworthy than 1 worth which is helpful for the rule factor. Combined of that segment is 52% which shows that portion of the difference has represented the primary factor. Extraction Sums of Squared Loadings and Rotation Sums of Squared Loadings has a similar incentive for the first part.

#### 4.3.3 TECHNOLOGICAL FACTORS

**Table 4.14: Descriptive statistics of technological variables**

	registrat ion type	Charging preference [Urban/ city areas]	Charging preference [Rural/ remote]	low mainte nance cost	drive per week	improve your charging experience	Safet y	low variety of models availab le in Ireland
Mean	1.69	1.79	1.97	1.04	1.86	1.91	2.45	1.16
Std. Deviation	1.017	1.082	1.161	.202	.628	.696	.555	.369

Distinct details guarantee that there is no missing qualities or mistake in the information assortment of respondents. All mechanical elements depend on the alternatives given in the poll. Standard deviation and the mean of qualities are fluctuating according to the quantity of alternatives accessible in each question.

**Table 4.15: Correlation Matrix**

	registration type	Charging preference [Urban]	Charging preference [Rural]	low maintenance cost	drive per week	improve your charging experience	Safety	low variety of models
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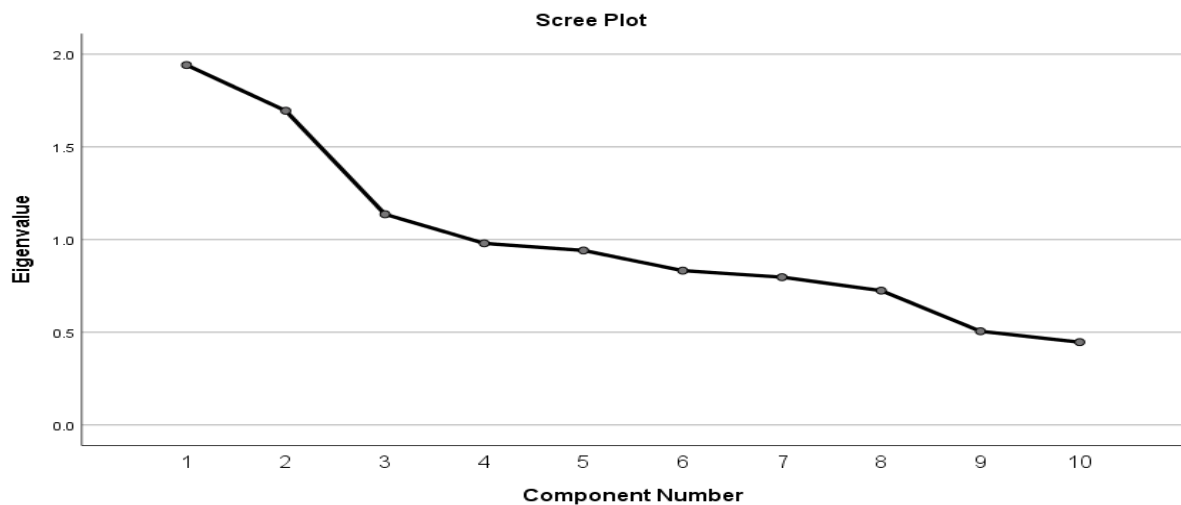
								available in Ireland
registration type	1							
Charging preference [Urban]	0.169	1						
Charging preference [Rural]	-0.006	0.285	1					
low maintenance cost	0.173	0.131	0.047	1				
drive per week	-0.105	-0.066	-0.187	-0.152	1			
improve your charging experience	0.13	-0.028	0.028	-0.004	0.118	1		
Safety	0.202	-0.036	-0.121	0.099	0.081	0.077	1	
low variety of models available in Ireland	0.143	0.233	0.014	0.214	0.061	0.166	0.16	1

All technological variables are remembered for the above connection network. To show the huge connection between one another at 90% and 95% certainty level, the relationship framework has been adjusted. More prominent than 0.15 qualities show more grounded associations with one another were not exactly that shows the helpless relationship with one another.

**Table 4.16: KMO and Bartlett's Test**

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.745
Bartlett's Test of Sphericity	Approx. Chi-Square	194.999
	Df	28
	Sig.	.000

Kaiser-Meyer-Olkin Measure scale is 0.745 which is more prominent than 0.500 thereby exceeding the supposition. The importance level is 0 which shows that KMO test is huge; the distinction esteem is 28 to exhibit that the turned segment range is required.



**Fig.4.22: Scree plot of technological factors**

Scree plot gave data of eigenvalues and after the initial 3 parts, the sharp reduction shows that it has required three-segment analysis.

**Table 4.17: Component Matrix**

VARIABLE	1	2	3
registration type	.586	.188	-.263
Charging preference [Urban/ city areas]	.583	-.371	.323
Charging preference [Rural/ remote]	.304	-.624	.361
low maintenance cost	.567	-.042	-.391
drive per week	-.220	.556	.499
improve your charging experience	.245	.401	.490
Safety	.315	.566	-.291
low variety of models available in Ireland	.617	.267	.257
Extraction Method: Principal Component Analysis.			

**Table 4.18: Component Correlation Matrix**

COMPONENT	1	2	3
1	1.000		
2	.177	1.000	
3	.166	-.102	1.000
Extraction Method: Principal Component Analysis.			
Rotation Method: Promax with Kaiser Normalization.			

#### 4.4 RELIABILITY ANALYSIS

The unwavering quality of an instrument or survey is worried about the consistency, solidness, and trustworthiness of the scores (McMillan, 2007). Hence, the inner consistency tried utilizing Cronbach's alpha for every competency in SPSS. In the event that the alpha value is higher than 0.9, in which consistency is phenomenal, and on the off chance that it is at any rate higher than 0.7, the consistency is adequate (Blunch, 2008).

##### 4.4.1 DEMAND PULL FACTORS

Cronbach's alpha is 0.720, which demonstrates an undeniable degree of inward consistency for scale with this sample.

**Table 4.19: Cronbach's Alpha**

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.720	.621	2

**Table 4.20: Correlation Matrix**

Inter-Item Correlation Matrix		
	Irish Government incentives/benefits	achievement of social reinforcement

Irish Government incentives/benefits	1.000	
achievement of social reinforcement	.450	1.000

Co-relation Matrix shows that the scale-based choice has a strong relationship with 0.450 values.

**Table 4.21: Total item statistics**

Item-Total Statistics					
VARIABLE	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Irish Government incentives/benefits	3.40	.888	.450	.203	.
achievement of social reinforcement	3.22	.793	.450	.203	.

Internal reliability related with the 5-thing Low to high Scale was researched utilizing Cronbach's alpha.1 Results showed that the alpha for the absolute scale was equivalent to .620. Assessment of individual thing insights recommended that the end of a few things would build the dependability of the scale.

#### **4.5.2 ONE SAMPLE T TEST**

In all multi-decision answers, all choices are changed over on the basis of "0" and "1", on which 0 is "not chosen" what other place 1 is "chose decisions' '. In this T-test, the test value is characterized at "1" to comprehend the chose and not choose esteem. Most chose alternatives are depicted in the illustrative examination by outlines.



#### 4.5.3 MULTIPLE-CHOICE SELECTED 1

**Table 4.22: One sample T-test**

Options	T	Mean Difference	95% Confidence Interval of the Difference	
			Lower	Upper
Option5	-23.156	-.572	-.62	-.52
Option6	-29.298	-.682	-.73	-.64
Option7	-28.479	-.669	-.72	-.62

Case – 1: One sample T-test for most affecting factors of research before purchase.

This segment incorporates that mean distinction is a lot higher and other more modest mean contrasts are produced. All outcomes are huge (Two tail importance level  $< 0.05$ ). Wretchedness score was measurably essentially lower (95% CI) than an ordinary misery score of 1.0. For choice 5  $t(401) = -23.156$ ,  $p = .000$ , For alternative 6  $t(401) = -29.928$ ,  $p = .000$ , For choice 7  $t(401) = -28.479$ . There was a measurably critical contrast between implies ( $p < .05$ ). Subsequently, it can dismiss the invalid speculation and acknowledge the elective theory.

#### 4.5.4 MULTIPLE-CHOICE SELECTED 2

Case – 2: One sample T-test for main reasons behind the adoption of BEV.

All outcomes are critical (Two tail importance level  $< 0.05$ ). Sadness score was measurably fundamentally lower (95% CI) than an ordinary gloom score of 1.0. For alternative 4  $t(401) = -31.443$ ,  $p = .000$ , For choice 6  $t(401) = -57.861$ ,  $p = .000$ , For choice 8  $t(401) = -36.248$ , For choice 9  $t(401) = -68.092$  and in choice 10,  $t(401) = -89.907$ ,  $p = .000$ , which reject the invalid speculation. There was a genuinely huge distinction between implies ( $p < .05$ ). Consequently, the invalid speculation and acknowledge the elective theory.

**Table 4.23: One sample T-test**

	t	Mean Difference	95% Confidence Interval of the Difference	
			Lower	Upper

V4	-31.443	-.711	-.76	-.67
V6	-57.861	-.893	-.92	-.86
V8	-36.248	-.766	-.81	-.72
V9	-68.092	-.920	-.95	-.89
V10	-89.907	-.953	-.97	-.93

#### 4.5.5 MULTIPLE-CHOICE SELECTED 3

**Table 4.24: One sample T-test**

options	T	P-value	Mean Difference	95% Confidence Interval of the Difference	
				Lower	Upper
option5	-38.672	.000	-.789	-.83	-.75
option8	-34.118	.000	-.744	-.79	-.70
option6	-47.809	.000	-.851	-.89	-.82
option7	-41.474	.000	-.811	-.85	-.77

Case – 3: One sample T-test for future influencing factors for better mass adoption

This segment incorporated that mean distinction is a lot higher and other more modest mean contrasts are produced. All outcomes are critical (Two tail importance level < 0.05). Sorrow score was measurably fundamentally lower (95% CI) than a typical gloom score of 1.0. For alternative 5  $t(401) = -38.678$ ,  $p = .000$ , For choice 8  $t(401) = -34.118$ ,  $p = .000$ , For choice 6  $t(401) = -47.809$ , For choice 7  $t(401) = -41.474$ , which reject the invalid speculation. There was a genuinely huge contrast between implies ( $p < .05$ ).

#### 4.6 TWO WAY ANOVA

**Case – 1:** Two-way ANOVA for charging inclination in both metropolitan and rural territories for both men and women. Generally, men have distinctive charging inclinations at

work or home or work while females do not have charging inclination. In two-way ANOVA factorial test, charging inclination at home, public charging or all spots is dissected by people.

For the Two-way ANOVA, the tested null hypothesis is:

- 1) There is no mean difference between male and female charging preferences.
- 2) There is no mean difference in between charging preference in rural and urban areas
- 3) Females have same charging preference as to male in both places.

**Table 4.25: Statistics of case 1**

Descriptive Statistics				
Charging preference [Urban/ city areas]	Charging preference [Rural/ remote]	Mean	Std. Deviation	N
1	1	1.29	.486	133
	2	1.57	.514	14
	3	1.15	.363	78
	4	1.23	.439	13
	Total	1.26	.456	238
2	1	1.14	.467	43
	2	1.67	.516	6
	3	1.50	.535	8
	4	2.00	.000	2
	Total	1.27	.520	59
3	1	1.18	.389	39
	3	1.00	.000	16
	4	1.00	.000	2

	Total	1.12	.331	57
4	1	1.50	.535	8
	3	1.50	.577	4
	4	1.36	.543	36
	Total	1.40	.536	48
Total	1	1.25	.472	223
	2	1.60	.503	20
	3	1.17	.377	106
	4	1.34	.517	53
	Total	1.26	.465	402

The Levene's Test of Equality of Error Variance clarifies the difference of the dependent variable. The invalid theory proposes that the fluctuation free factor is equivalent across the gathering which has been dismissed by the Levene's Test which clarifies that with p-value 0.026(<0.05).

**Table 4.26: Levene's Test of equality error**

F value	df1	df2	P – Value
7.995	13	388	.000

Collaboration impact between two factors and gender as the dependent variable, it is seen than p-value is 0.034 which is under 0.05 which reject the invalid theory. Charging inclination in metropolitan territories additionally has critical P-esteem 0.006 which is under 0.05 which reject the invalid hypothesis.

**Table 4.27: Test of between-subjects effects (Charging preference)**

Dependent Variable: Gender				
Variable	df	Mean Square	F	P- Value

Charging preference [Urban city areas]	3	.854	4.218	.006
Charging preference [Rural remote]	3	.387	1.912	.127
Charging preference Urban city areas * Charging preference Rural remote	7	.446	2.200	.034

This shows that central zones BEV clients have explicit charging inclination while rural territories BEV clients have not got major charging inclination. In general, men have explicit charging inclination while women have not or lower charging inclination.

**Case – 2:** Two-way ANOVA for Irish government impetuses and cultural impact accomplishment influence the future inclination to acquisition of BEV clients. In two-manner ANOVA factorial investigation, Irish government benefits and cultural impact is dissected by inclination to purchase another BEV in future.

For the Two-way ANOVA, the tested null hypothesis is

- 1) There is no mean difference between Irish government benefits and societal influence.
- 2) There is no mean difference in between the effect of Irish government benefits and societal influence on future preference.

**Table 4.28: Descriptive statistics of case 2**

Descriptive Statistics				
Dependent Variable: preference to buy another BEV in future				
Irish Government incentives/benefits	social reinforcement	Mean	Std. Deviation	N
1	1	1.00	.000	8
	3	1.50	.577	4
	4	1.00	.000	2

	5	1.00	.000	2
	Total	1.13	.342	16
2	1	1.00	.000	4
	2	1.47	.516	15
	3	1.71	.470	17
	4	1.47	.516	15
	5	1.00	.000	2
	Total	1.49	.505	53
3	1	1.75	.463	8
	2	1.33	.492	12
	3	1.15	.357	101
	4	1.60	.627	55
	5	1.44	.527	9
	Total	1.34	.517	185
4	2	2.00	.000	2
	3	1.26	.554	38
	4	1.28	.510	72
	5	1.40	.516	10
	Total	1.30	.525	122
5	3	1.00	.000	6
	4	1.00	.000	2
	5	2.25	.856	16
	Total	1.83	.917	24

Total	1	1.30	.470	20
	2	1.45	.506	29
	3	1.23	.453	166
	4	1.41	.571	146
	5	1.72	.793	39
	Total	1.36	.559	400

The Levene's Test of Equality of Error Variance clarifies the significant difference of the needy variable. The invalid speculation recommends that the fluctuation in the reliant variable is equivalent across the gathering which has been dismissed by the Levene's Test which clarifies that with p-esteem 0.000(<0.05).

**Table 4.29: Levene's Test**

Levene's Test of Equality of Error Variances			
F- Value	df1	df2	P- Value
8.418	20	379	.000

Irish Government incentives/benefits\* social reinforcement has p-value less than 0.05 which reject the null hypothesis.

**Table 4.30: Test of between subjects' effects (preference to buy another BEV)**

Variable	Df	Mean Square	F	P-Value
Irish Government incentives/benefits	4	.272	1.078	.367
social reinforcement	4	.258	1.021	.396

Irish Government incentives/benefits* social reinforcement	12	1.337	5.303	.000
--	----	-------	-------	------

This shows that Irish government impetuses and cultural impact consolidated variable influence the future purchasing inclination of another BEV. Cultural impact has a P-value more noteworthy than 0.05 which shows that it influences lower to future purchasing inclination.



## **CHAPTER 5: DISCUSSION & CONCLUSION**

The main aim of the research is based on the three objectives which deal with multiple variables and components and to analyse their scope which impacts the adoption of Electric Vehicles in Ireland. A survey was conducted across the different age groups, and professions to understand the experience of driving Electric Vehicles and lastly; the initiatives undertaken by the Irish Government which might be the incentive schemes or increasing the charging points to promote the sale of Electric Vehicles.

Multiple factors like Technological factors, Socio- Demographic factors, Demand-Pull factors, Component Factor analysis, Improvement factors of adoption and various methods like Customer Survey, Sampling, Best-Worst theory, Multinomial Logic, 2- Way ANOVA have been utilized for the data collection and analysis. Based on the results obtained from the above-mentioned methods considering different set of variables and components, the conclusion has been written.

### **5.1 EV DISCUSSION ON GLOBAL EV MARKET – CHINA & U.S.A.**

There are a small number of nations and economic blocs where the market for Electric Vehicles has been growing significantly over the past few years considering the opinion of the people on the EVs and the steps undertaken by their governments in this initiative. They are China, Europe, and the USA.

Chinese Original Equipment manufacturers (OEM) have been working on their e-powertrains constantly to increase the efficiency of the whole vehicle system and they also strive to provide the best experience to their local customers by coupling the latest cyber related technologies and Internet of Things (IOT) integrated with the vehicles at affordable cost. In addition to this, the Chinese government has also taken various initiatives to push the adoption of Electric Vehicles among its people. This has resulted in China comprising approximately 50 % of the global EV market from nearly 8 % in 2012.

In the United States market, EV sales have been slow compared to their competitors in China and Europe. The reason being the federal tax policies on the Electric Vehicles and the decline in the popularity of Hybrid Vehicles. However, Tesla has created popularity among the people to opt for the Electric Vehicle although the cost of the vehicle has been on the higher side compared to the fuel run vehicles. The United States constitutes roughly around 15 % of the global EV market.

Coming to the European market, there are various models of Electric Vehicles which are in the affordable range for the people to choose from. Norway, Iceland, Netherlands, and

Sweden have shown rapid growth in the sales of Electric Vehicles over the recent years. The main reasons are the Sustainability Awareness among the people and the steps taken by their governments in this direction to promote higher adoption of EVs. This has resulted in Europe contributing approximately 30 % to the global EV market share.

Analysts have mentioned that slowly, the Irish market is moving towards the goal of achieving 1 million Electric vehicles by 2030. However, they feel that the government must initiate more steps like setting up charging points, providing incentive schemes and create sustainability awareness among the youth in order to achieve the target by 2030. Volvo, Audi, and Nissan have been majorly focusing on the Irish market in future for their electric vehicle models.

It is noted about the growth of EV market in China and the market share in the global EV market. There are couple of reasons for the extensive growth of China since 2016. Even though there are huge investments on EV R&D in both Europe and U.S.A, the government intervention is very limited when compared to China. The Chinese government has been encouraging many start-ups across the country and helping the domestic manufacturers grow. Apart from the investments, it has been providing extensive subsidies to EV consumers which has fuelled the growth of EV. However, in the recent past Europe has been rising on the EV sales majorly from the Scandinavian countries and has occupied the second place in terms of EV sales as well as the number of models available with China in the first place and U.S.A in the third place. Tesla has been increasing its footprint across U.S.A with more support from the government. The U.S.A must emulate all the steps from China in order to compete and grow.

## **5.2 SOCIO-ECONOMIC PROFILES OF EV OWNERS**

Through socio-demographic factors, it is noted that feedback from men were higher than women feedbacks in all age groups. In Ireland, the average age is between 30-45 for the people to buy the Electric Vehicles. There are comparatively less people who are aged below 35 and more than 65 aged, matured BEV drivers. Leinster has major BEV drivers in contrast with other three regions. Munster, Connacht, and Ulster have a lower number of BEV drivers according to CSO registration information. A large portion of the BEV drivers' yearly pay is more than 30,000 Euro. Major BEV clients are from the services division, Information Technology (IT) and designing area occupation. The findings of the discussion are below, they are:

- ✓ Better government motivating forces and cultural support influence decidedly to the adoption of BEV. Quality investigation showed internal consistency among the received responses. Social impact and Irish motivations have solid co-connection with one another. The vast majority of the BEV clients accepted that BEV improves the sense of contribution towards the sustainability movement.
- ✓ One sample T-test shows that sustainability factor and cost rebates do not influence the future mass selection in BEV drivers' perspective. Better driving reach at a lower cost and additional charging focuses will improve future adoption of EVs.
- ✓ Two-way ANOVA test rejected the null hypothesis of charging preference for men and women in case 1 which talks about the charging preferences in both men and women in metropolitan and rural areas. Both have the same kind of charging preferences which is verified by the Levene's Test of Equality. From the case 2, it is observed about the future inclination for the adoption of EV. Therefore, the test of Equality proved that future adoption will be affected by Irish government incentives and societal reinforcement. Although, past research on BEV policymakers showed that Irish government incentives do not have a significant effect on the adoption in the viewpoint of policymakers and BEV dealers.
- ✓ The research work was initiated keeping the mind to achieve the three main objectives drafted which is to thoroughly understand the present Irish EV market and to analyse the factors which influence the people to buy EV by conducting the survey among the people who have already bought the EV and the ICEV vehicles as well in order to understand what influenced them for their adoption of vehicles. Based on the factors and the survey data, recommendations have been made which might help the future research work as well as for the policies or EV marketing programmes if conducted in future to boost the sales of EV.
- ✓ From the analysis of the EV markets of China and the U.S.A, it is noted about various policies and incentive schemes undertaken by other governments to boost the sales of EV with the policies by the Irish government. The main idea of the research is to provide the global EV scenario, understand the gap, various factors contributing to them and to bridge the gap by suggesting the recommendations, factors which contribute for bridging and awareness programmes which need to be initiated not only by the government but also from various organisations which might increase the sales of EV in Ireland.

- ✓ From the government perspective, it has to make EV as VAT free or subsidy based on the value of the vehicle, with the likes of China and U.S.A which did on their local EV manufacturers and Tesla, respectively.
- ✓ In conclusion, after detailed survey and analysis of various factors and theories, it would not be able to zero in on a single factor or area for the present results or for the future recommendations. A collective approach has to be undertaken in all the areas to move towards the sustainability goal. Although there has not been a significant growth of Electric Vehicles, the Irish government has set a target for 2030. It is working on various schemes, policies and work is going towards building the adequate infrastructure for more people to adopt EVs rather than the combustion vehicles in future.

## **CHAPTER 6: RECOMMENDATIONS AND POTENTIAL DEVELOPMENTS OF THE RESEARCH**

Initially, because of the type of the subject undertaken, quantitative information has been considered for the research work. In the quantitative information, 20 factors were chosen from previous works and research papers. However, few factors in BEV are excluded like the way EVs are driven, amount of fuel consumption for methodical and non-methodical driving etc. Furthermore, there were no face-to-face meetings and personal discussions taking place due to COVID-19 outbreak from 2020. Thirdly, SPSS technical instrument was utilized to consolidate the results from the available survey data. Nonetheless, Irish BEV adopters have an exceptionally low number in contrast with ICEV adopters. Because of this, it would be more complex to study the whole Irish automobile market. Moreover, this research just spotlights on Irish BEV market; but is it significant to promote the sale of EVs across the world for a sustainable environment (Jin et al., 2020).

The motivating factors for the adoption of EV varies from country to country. However, the common points are:

- ✓ To move towards a sustainable environment is the main motivating factor.
- ✓ Increase in the rates of fuel in the Asian countries especially.
- ✓ Incentive schemes being offered on EV models from the government.
- ✓ Fast- charging and charging availability at home.

### **6.1. RECOMMENDATIONS FOR FUTURE RESEARCH WORK**

The present research work has been completed based on multiple information sources like the research papers, government data and online survey. The research work was started keeping in mind the information and the recommendations provided would act as a guide to refer for future students and other researchers for their research. The plan was to personally meet the managers of the EV showroom, some of the people from the administration from various counties, people who own luxury cars and a few members of SIMI but due to the lockdown, the task could not be completed. Interviewing people from the other counties would have helped in analysing why the sales of EV is higher compared to other parts of Ireland and the initiatives undertaken by them.

So, first recommendation for the future students who undertake the research work is to personally meet and conduct a face-to-face interview which would make the work easier in

terms of data analysis and in further recommendations. Second recommendation would be to contact their known people in other countries like U.S.A or China or Norway to interview EV owners and EV showroom people to understand their view and opinions on the same. The research work can also be conducting a Qualitative research which can be achieved by conducting a personal meeting and interviews with the key people of the automobile industry which makes us understand better perspectives along with limited data and analysis. This was the limitation which was faced during the research work due to the COVID-19 outbreak and continuous lockdowns.

The main objectives of the research have been fulfilled. The scope of variables impacting the adoption have been discussed in the initial chapters by considering various factors and analytical data. The experience and perspective of the individuals have been covered by conducting the online survey and analysing the received data by various technical equipment and formulae. Findings and recommendations have been covered in Chapters 5 & 6 which is the motive of the last objective.

### **6.2.1 RECOMMENDATIONS TO THE GOVERNMENT and SIMI**

In order to achieve the target of 1 million EV on road by 2030, the government needs to take steps from today.

1. Firstly, prior to the announcement of incentive schemes or policies, it has to understand the mindset of the people and opinion towards adoption of EV. In order to do that, it has to conduct an annual survey of recently bought IC vehicle owners and analyse the data.
2. Parallel to that, it has to increase the public infrastructure of the charging points by creating a charging farm in a junction area or near to stopovers so that the speed of the passing vehicles would be moderate enough to observe the charging points.
3. Thirdly, they have to bring in a well-known celebrity as a brand ambassador for the EV promotion.

SIMI Ireland is also doing a great job in terms of promoting EV. The EV sales data, how EV helps in reducing emissions and the information about both EV and Hybrid vehicles are present on the website. Apart from these, they have to:

1. To conduct public awareness programmes at regular intervals, take initiatives to educate more people in smaller counties by understanding their daily commute schedules for the adoption of EV in place of ICE vehicles.

2. To upload a video of the global EV scenario and how Ireland can contribute with more adoption.

### **6.3 LIMITATION**

The absence of a primary qualitative interview measure also creates problems in incorporating detailed analysis regarding the battery usage in Irish market. The research study failed to introduce the information regarding the lack of female drivers in Irish market. Due to such lack of information, the research study failed to identify the pattern of usage among women owners of BEV in the Irish market.

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