



Electric Vehicles adoption process from a consumer perspective: A System Dynamics Model

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1 Introductory Note

Recently, with hard evidences of the Global Warming problem, every industry has become more concerned with the its environmental impact on the world. This concern is a big motivator to innovate current technologies to be more clean and use renewable energy sources, to promote a sustainable growth with a less polluting behaviour.

One of these industries is the car industry. According to [1] and [2], in 2019, the transportation sector was responsible for almost 30% of the total CO₂ emissions in European Union, and nearly 20% worldwide, which means that the use of electric vehicles is a necessity to our planet's health and also means that it is an in-development market with a remarkable on-going year-over-year (YoY) growth.

Hence, so I could have a more clear picture of how the EV market would evolve in Portugal, I decided to study the adoption process of electric vehicles based on Portuguese market indicators. This document is the result of that study and provides an explanation on the process of adoption of electric vehicles as a personal one, taking into account current and future: population, adoption ration, price difference, battery range and others factors that are essential to the decision making process of choosing an EV as a personal vehicle.

The developed dynamic model was implemented using Vensim [3, 4, 5], based on the different works of Pedro Ferreira, Yue Xiang *et. al* and Tim Bongard [6, 7, 8].



2 Abstract

With the growing concern for the environment, the market of electric vehicles has great potential to reduce the CO₂ emissions of transporting industry. With that in mind, this document addresses the adoption of electric vehicles (EVs) as a means of personal transport, in order to replace the internal combustion vehicles (ICVs) to reduce pollution emission and promote a cleaner and more healthier environment.

This document discusses previous work on this field and purposes a system dynamics model to better understand the current and future growth of this market and what factors influence it the most.

This study approaches a series of possible factors such as **driving range**, **price difference** between EVs and ICVs, **charging time**, among others and analyses how each of these factors can impact the market and in what scale/importance.

From the scenario and simulation results, it is possible to conclude that:

- A high density recharge infrastructure is essential to promote market's adoption;
- Government subsidies are the major promoter of the electric vehicle industry adoption and evolution, especially in the early stages of this market;
- Charging prices and electric vehicle price difference compared to ICVs are today's primary factor that customers consider when thinking of purchasing an EV;
- Further development on the underlying batteries technology with the goal to improve performance and reduce charging time is an important necessity, since it can be a major reason to increase the electric vehicles adoption rate.

These conclusions agree on what most recent work in this field has been achieving and are also an interesting contact point with the work developed by Pedro Ferreira [7].

All the work related with this study can be found in <https://github.com/vascoalramos/ev-adoption-model>.

3 Previous Work

Last year, Pedro Ferreira developed a study, present in [7], addressing the evolution of the electric vehicles adoption on Portugal, from a perspective of competitiveness between companies through a series of factors such as: **Average Quality**, **Range**, **Top Speed**, among others.

This study focused on the perspective of market share between different manufactures in function of their weaknesses and strengths. The dynamic model that was implemented in this work can be seen in figure 1.

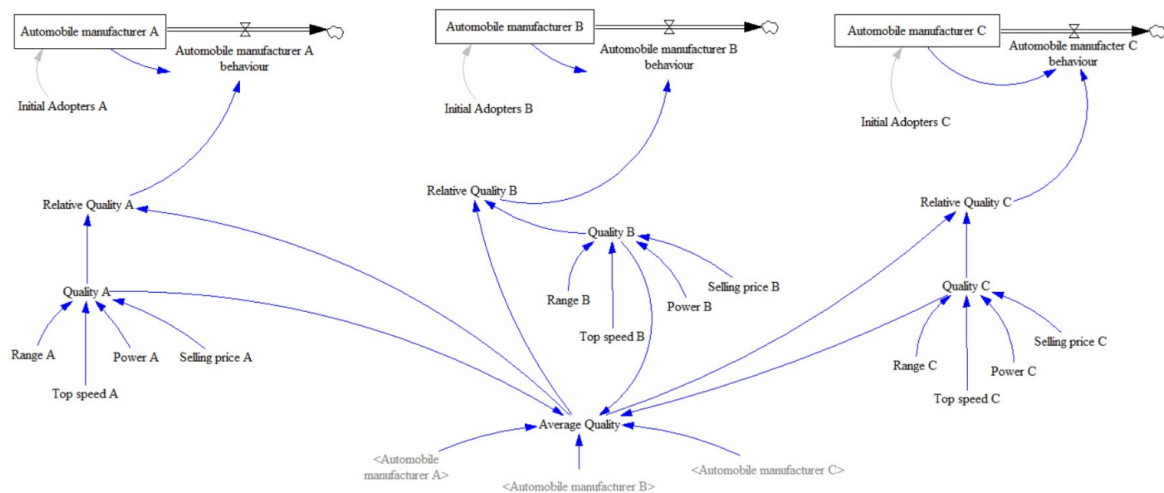


Figure 1: Stock and Flow Diagram of Electric Vehicles adoption. Source: [7]

In this study, the author analyzed the market share evolution, average quality and relative quality of electric vehicles of throughout a period of 12 months. These analysis allowed the author to conclude that, given the studied scenario, the most important decision factors would be: **price** and **charging time** and that the manufacturer with the best balance between these two factors, regardless the initial adopters, would eventually take up most of the market share of electric vehicles.

Although this study brings helpful insight to what factors could make a specific manufacturer succeed over the others, it fails to provide an understanding on how the EV market would evolve over the next years taking into consideration important factors to the consumers choice. As I said in section 1, economical concerns are more and more present in today's society and it's helpful to better understand how to EV market will evolve to better grasp what will be the contribution of transport vehicles to the overall reduction of CO2 emissions and what are the factors that most dictate the growth of this market.

Having that said, this works builds on the insights provided in [7] and enhances it with a more global vision of the growth of the entire EV market that allows to grasp a broad perspective and have a means of comparing with the market of fossil fuel vehicles.



4 Adoption Factors

As mentioned in 2, this study is consumer-centred, which means that the study of adoption of electric vehicles is done taking into consideration the factors that the consumer is more "passionate" about when choosing an electric vehicle. Therefore, the logic way to find these adoption factors is to base our selection on consumer-focused surveys. Particularly, the selection of factors that were chosen to this study were based on the information gathered from the surveys referenced in [6, 8].

Having said that, since the model was mainly based on [6], the adoption factors included are very similar with the base model, with a few additional ones that I found to be as significant as the ones already taken into consideration. Thus, as referenced in [6], there are four technical factors that have the greatest impact on the consumer decision: **driving range**, **price**, **recharge infrastructure** and **recharging time**. In addition to these factors, we must also include the **effectiveness of advertising** such vehicles, the **word of mouth effect** and last, but not least, the **environmental concern effect**.

4.1 Driving Range

The maximum driving range of an EV is mostly related to the performance of the battery. Nowadays, the improvements in lithium-ion battery technology allows driving ranges on average around 200km - 300km. However, following current events, there have been some interesting developments in the field, promoted by Tesla and what currently is one of the downsides of EVs (when compared to the autonomy values of fossil fuel cars) could, in the near future, be a major advantage.

4.2 Price

The current purchase price of an electric vehicle is, in general, twice that of a comparable fossil fuel car (e.g. gasoline or diesel). With the mass production of more and more models, this price will eventually go down, but how fast this will happen is the difference between a more quick or slow mass adoption of EVs, which actually is kind of a paradox.

The problem with this price point is that the general consumer is not willing to pay this amount of money for an EV in contrast with governments and fleet operators that are more open to these types of purchases. However, one key factor that has been playing a big role as an incentive to the general consumer is the benefit most governments have been allowing when buying an EV, such as subsidies and/or tax reduction.

4.2.1 Fixed Price

The high purchase price of an EV is mostly due to the high battery prices and low production volumes. However, this premium cost for EVs is still compensated by the low cost of electricity compared to gasoline. The predictions state that, over time, the electric vehicle costs will decrease as the result of ongoing R&D, learning effect and mass production.

4.2.2 Variable Price

EVs, in addition to benefiting from the lower cost of electricity when compared to fossil fuels, are also influenced by other "external" factors that do have an impact on the variable costs difference between an EV and fossil fuel vehicles, such as the rising oil prices which could make fossil fuel vehicles less attractive and the lower maintenance costs. However, battery devaluation and the effect of environmental temperature have



their own impact too, being some of the greatest disadvantages of EVs. Furthermore, there are subsidies that should stimulate the early adoption of electric vehicles.

Simplifying, the variable costs depend on a set of different values: the **influence of oil** and **electricity price**, **subsidies**, **maintenance costs**, **R&D influences** and **devaluation of the battery**. Finally, among all these variable costs, the subsidies are the best values to influence and manipulate.

4.3 Recharge Infrastructure

Availability of charging infrastructure is essential for the market adoption of electric vehicles. Furthermore, the different charging alternatives, for instance the fast charging stations and the infrastructure density have a big influence on the electric vehicle's range and charging times, which additionally affects the possible market share. Which this means is that a high density of infrastructure charging locations (and fast recharge times) makes more acceptable a lower maximum driving range in comparison with a low density and slow recharge times.

4.4 Recharging Time

In overall an electric vehicle requires a battery capacity of 65kWh or more to drive a 300km range. This means that it will take 5 - 6,5 hours to recharge the EV in one's garage. In the case of three phase charge station, that are more common in large homes, offices and firms, it will take approximately 1 - 1,5 hours to fully recharge the vehicle.

Besides the two types of recharging possibilities, there is also another which is mentioned as a fast charging station, despite being a lot faster, has some disadvantages because they are too expensive, making it much more difficult (almost impossible, at least right now) to include this type of research into the electric vehicle.

4.5 Effectiveness of Advertising

The adoption from advertisement depends on the advertising effect. This means that, depending on how effective the advertisements are, the rate of adoption will be faster or slower.

The advertising effect works in a way that the adopters made the decision on buying an EV solely on the advertising strategy (websites, pilot projects, commercials, etc.) and the major obstacle to the success of this effect is the newness of EVs that keeps potential adopters from buying one.

4.6 Word of Mouth Effect

The adoption by word of mouth is estimated taking into consideration Portugal's population, a contact rate and the adoption fraction that will be further explained in the next section.

This factor creates an upper limit for the adoption model and has a dissemination behaviour similar to a contagious disease, that is, the greater the number of people adopting EVs and talking about their potentially positive experience, the greater the effectiveness of the word of mouth effect. This means that in early stages of EVs market introduction this is a minor factor, but over time, becomes a much bigger influence on the market growth.



4.7 Environmental Concern Effect

The last factor is selected over the observation that more and more people have a very real concern about our planet and environment and being the fossil fuels industry one of biggest responsible for worldwide pollution, this factor is more and more real and is supposed to have a big impact on the EV market in the near future.

5 System Dynamics Model

This chapter provide explanation and details regarding the developed model in Vensim. Before further scrutinize the implementation and for the sake of simplicity **some of the variable definitions are going to be presented as graphs**. This is because, as state before, **this study is mostly based on the results of surveys**, hence, the best way to define some of the variables is to use the resulting data form those surveys, instead of a pure mathematical definition.

In the **cases where the variables function were define through data**, this **data was based from [6, 7] and adapted to the Portuguese scenario and reality using external sources**, such as news articles [9, 10, 11, 12].

Finally to implement this types of variable functions, it was used the feature **Lookups** of Vensim, showcased in section [13].

5.1 Proposed System Dynamics Model

An can be seen in the figure 2, the developed model takes into account all the factors discussed in 4.



Figure 2: Complete Model of EV Adoption Process



Before going into detail on each factor representation and associated relationships, let's first explore the adopted layout with **Potential Adopters** → **Actual Adopters** and **Discard Rate**.

5.1.1 Potential Adopters → Actual Adopters

This model starts with the potential adopters, which are the current passenger vehicle drivers and account for approximately 6.5 million Portuguese drivers. Taking the model into consideration we can clearly see that through the rate of adoption a fraction of these 6.5 million drivers will become adopters each year, that is, will purchase an EV. The adopters variable has an initial value of 16 000 drivers, that represents the Portuguese drivers that already have an electric vehicle in 2020.

5.1.2 Discard Rate

The bass diffusion model is frequently described as a *first-purchase* model because it does not grasp the situation where the product is consumed, upgraded or discarded. What this means is that the bass diffusion model is not able to represent the inverse situation (Actual Adopters → Potential Adopters). The implemented model has the capability to capture that situation in the sense that an EV can, for instance be discarded or upgraded due to the battery lifetime or dissatisfaction. This event is modelled with the battery lifetime that has a value of 15 years.

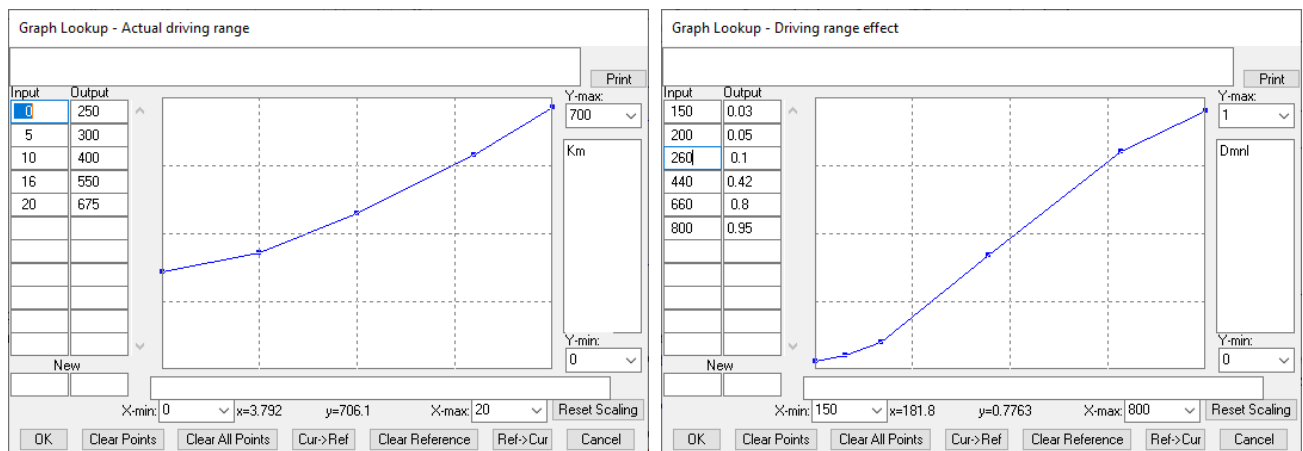
5.2 Variables Definition

The **variables** that are going to be **explored with more detail in the next sub-chapters** are the ones that were **based on data from the surveys**. It is going to be presented the graphs associated with each one of these variables and will also be explored its context beyond the number representation. All the remaining variables (that are simple mathematical functions or constants) are summarized in the table 2, further ahead.

5.2.1 Driving Range

Given the current average capacity of the batteries on the market and the past years of evolution, figure 3a describes the current average of EV's maximum range at 250km, at year 0 (2020), and an evolution to 300km after 5 years (2025), all the way to 675 at 2040. Obviously the further we predict, the less reliable are those predictions, so some of these number are, as said, just predictions and can be wrong, but are the best possible predictions given the data we have today.

Figure 3b shows us the acceptance percentages of EVs maximum range according to the consumer's responses on the surveys. The graph shows us that, even today, the average driving range it's not very well accepted, since only 5% - 10% of the enquired customers would buy a vehicle with that range. The minimum driving range that has a certain degree of acceptance is 440km, so it can be expected that this factor could have a big positive impact on EV sales from 2030. Obviously this is not the only factor to consider as we will see further ahead that a good recharge infrastructure with high charging speeds could lessen the need for higher driving range values.



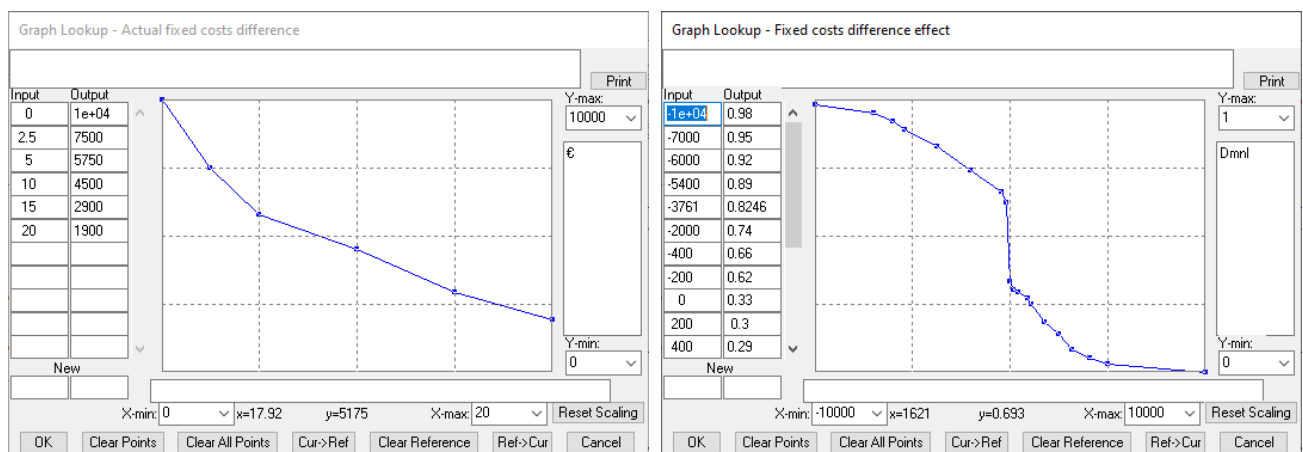
(a) Actual Driving Range Data

(b) Driving Range Effect Data

Figure 3: Driving Range Functions

5.2.2 Price

Considering the high costs of the lithium-ion batteries, electric vehicles tend to have a higher selling price than combustion models of the same range. Figure 4a shows us precisely that. At 2020, 0-year, the average price difference between an EV and an ICV is 10 000€, which means that, an electric vehicle costs 10 000€ more than a similar ICV model. After 5 years, this difference is around 5000€, that is, in 5 years the difference of prices has reduced over 50%. At 2040 the price difference is in all-time low of 1900€, reducing the price difference to 20% of its initial value.



(a) Actual Fixed Costs Difference Data

(b) Fixed Costs Difference Effect Data

Figure 4: Fixed Costs Difference Functions

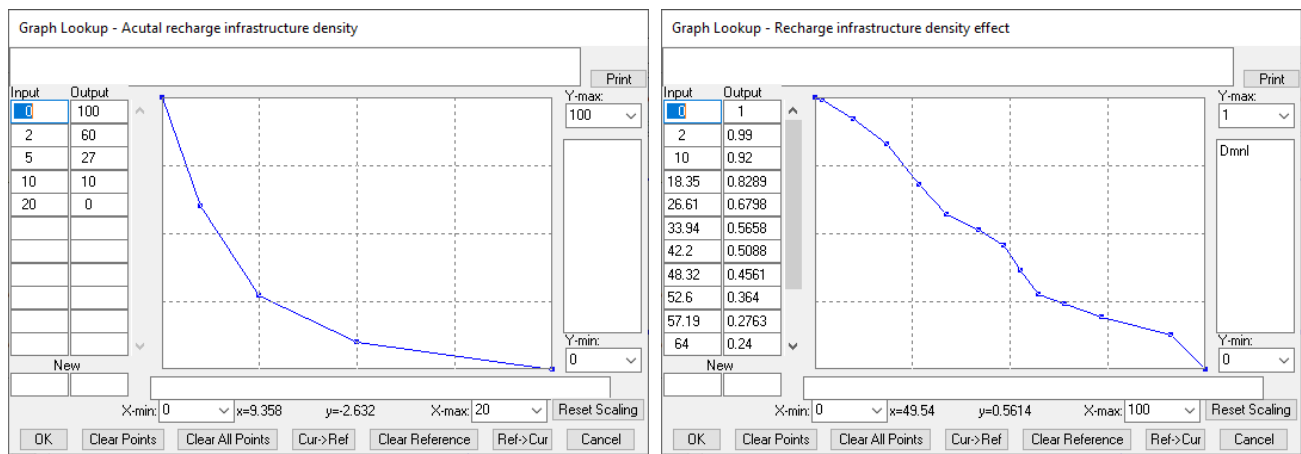
Figure 4b shows us the acceptance percentages of these differences in price regarding EV and ICV models. From the graph, we can understand that the majority of people can only consider purchase an EV when its price is the same or less than an equivalent ICV. If we would only consider this factor, we would wrongly think that, even 20 years from now, only a minority of the population would buy an EV. The aspect that we must have in consideration is the variable costs such as oil pricing, government subsidies and/or tax the reduction,



electricity price. Some of these factors significantly amortize the price difference, either instantly or over time.

5.2.3 Recharge Infrastructure

As said before, the recharge infrastructure is the network of recharging stations (public or private, that is, home recharge "stations" are considered as private stations) scattered all over the country and it is one of the most important differences between the EV and ICV markets. As figure 5a clearly demonstrates, today we have an average density of 100km between each station and this value is actually deceitful, because it does not represent evenly all Portuguese territory. The predictions suggest that in 20 years, Portugal will have an average density of recharge stations around 0km - 5km, which is actually very optimistic.



(a) Actual Recharge Infrastructure Density Data

(b) Recharge Infrastructure Density Effect Data

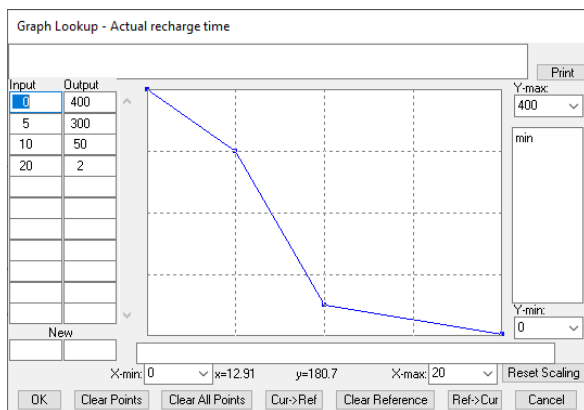
Figure 5: Recharge Infrastructure Density Functions

Figure 5b allows us to better understand what the consumer thinks of this factor. According to the surveys, the great majority of the population believes that the acceptable recharge infrastructure density is between 0km and 40km.

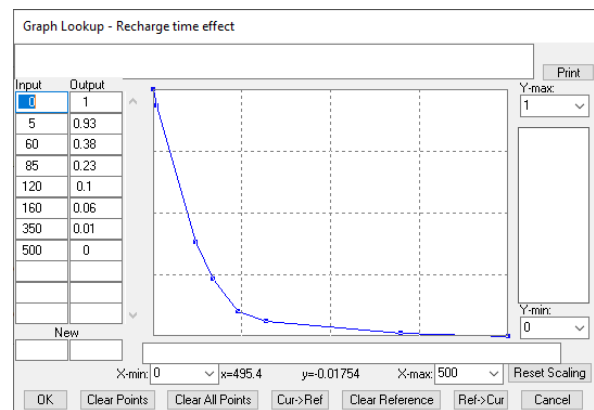
5.2.4 Recharging Time

If we own an ICV and we are close to run out of fuel, the process of refuel our vehicle could not be simpler or faster, taking no more than 5 minutes to fill the tank. In the case of electric vehicles the currently reality is not quite the same, since, currently, the action of completely recharging a EV can take up to 6,5 hours. Figure 6a, show us that 5 years from now, the process of recharge an EV could be less time consuming, taking at most 5 hours to fully charge an EV and that 20 years from now the same process will be significantly faster taking 2 minutes to be completed, thanks to the switch of a discharged battery (that will be promptly recharged) for a fully charged one.

In figure 6b we can see that more than 40% of the enquired population considers that the acceptable time to fully recharge an EV battery (or switch it with a recharged one) should be less than 50 minutes.



(a) Actual Recharge Time Data



(b) Recharge Time Effect Data

Figure 6: Recharge Time Functions

5.2.5 Environmental Concern Effect

More and more people are concerned with future of our planet, so, this concern has an impact on EV sales. As can be seen in figure 7, at yearly stages this concern has a boost effect on sales around 5%, this value starts to increase at fast pace in the next 12,5 years and then, as EVs become more and more common, its growth starts to slow down due to the loss of the novelty effect and the loss of the big disruption impact on people's lives and pollution percentages.

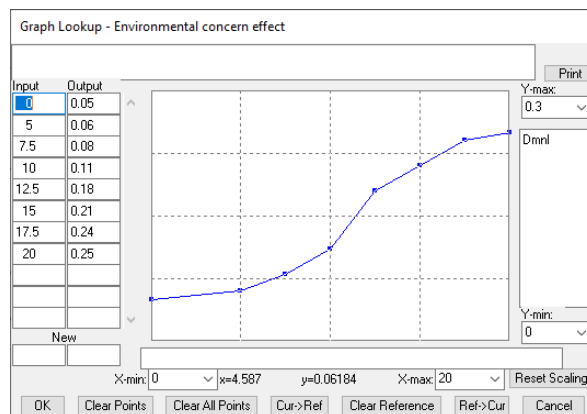


Figure 7: Environmental Concern Effect

5.3 Weight of Factors

This section shows how each factor influence is weighed on the implemented model. Table 1 summarizes how the weight is distributed among all the factors.

	Driving Range	Charging Time	Price Difference	Recharge Infrastructure	Environmental Concern
Weight	0.3	0.06	0.56	0.04	0.04

Table 1: Weight of Factors in Vensim Model



5.4 Summary of Model Variables

Table 2 summarizes the entire model, listing all variables with its equations/initial values and units.

Variable	Equation/ Initial Value	Units
INITIAL TIME	0	Year
FINAL TIME	20	Year
Potential Adopters	$INTEG(\text{Discard Rate} - \text{Rate of Adoption}, 6.5 \times 10^6)$	Person
Rate of Adoption	$\text{Total adopters from Driving Range} + \text{Adopters from ads} + \text{Total Adopters from Price} + \text{Total adopters from Recharge Infrastructure} + \text{Total adopters from Recharge Time} + \text{Total adopters from Environmental Concern} + \text{Adopters from Word of Mouth}$	Person
Adopters	$INTEG(\text{Rate of Adoption} - \text{Discard Rate}, 16\ 000)$	Person
Average EV lifetime	15	Year
Discard Rate	$0.003 * (\text{Rate of Adoption} / \text{Average EV lifetime})$	Person
Potential adopters per year	200 000	Person/Year
Environmental concern effect	$WITH\ LOOKUP\ (Time, ((0,0)-(20,0.3)), (0,0.05), (5,0.06), (7.5,0.08), (10,0.11), (12.5,0.18), (15,0.21), (17.5,0.24), (20,0.25)))$	
Adopters from environmental concern	$\text{Environmental concern effect} * \text{Potential adopters per year}$	Person
factor environmental concern	0.04	
Total adopters from Environmental Concern	$\text{factor environmental concern} * \text{Adopters from environmental concern}$	Person
Actual driving range	$WITH\ LOOKUP\ (Time, ((0,0)-(20,700)), (0,250), (5,300), (10,400), (16,550), (20,675)))$	Km
Driving range effect	$WITH\ LOOKUP\ (Actual\ driving\ range, ((150,0)-(800,1)), (150,0.03), (200,0.05), (260,0.1), (440,0.42), (660,0.8), (800,0.95)))$	
Adopters from Driving Range	$\text{Driving range effect} * \text{Potential adopters per year}$	Person
factor driving range	0.3	
Total adopters from Driving Range	$\text{factor driving range} * \text{Adopters from Driving Range}$	Person
Actual fixed costs difference	$WITH\ LOOKUP\ (Time, ((0,0)-(20,10000)), (0,10000), (2.5,7500), (5,5750), (10,4500), (15,2900), (20,1900)))$	€
Fixed costs difference effect	$WITH\ LOOKUP\ (Actual\ fixed\ costs\ difference, ((-10000,0)-(-10000,1)), (-10000,0.98), (-7000,0.95), (-6000,0.92), (-5400,0.89), (-3761,0.8246), (-2000,0.74), (-400,0.66), (-200,0.62), (0,0.33), (200,0.3), (400,0.29), (900,0.27), (1100,0.25), (1800,0.18), (2500,0.14), (3200,0.08), (4100,0.05), (5000,0.03), (10000,0)))$	
Actual variable costs difference	$WITH\ LOOKUP\ (Time, ((0,-1000)-(20,1000)), (0,912), (13,0), (20,-707)))$	€
Variable costs difference effect	$WITH\ LOOKUP\ (Actual\ variable\ costs\ difference, ((-5000,0)-(-5000,1)), (-5000,1), (-3000,0.93), (-800,0.63), (100,0.12), (400,0.07), (2100,0.01), (5000,0)))$	
Adopters from costs	$(\text{Fixed costs difference effect} + \text{Variable costs difference effect}) * \text{Potential adopters per year}$	Person
factor price difference	0.56	
Total adopters from Price	$\text{factor price difference} * \text{Adopters from costs}$	Person
Advertising effect	0.00025	
Adopters from ads	$\text{Advertising effect} * \text{Potential Adopters}$	Person
Actual recharge infrastructure density	$WITH\ LOOKUP\ (Time, ((0,0)-(20,100)), (0,100), (2,60), (5,27), (10,10), (20,0)))$	
Recharge infrastructure density effect	$WITH\ LOOKUP\ (Actual\ recharge\ infrastructure\ density, ((0,0)-(100,1)), (0,1), (2,0.99), (10,0.92), (18.35,0.8289), (26.61,0.6798), (33.94,0.5658), (42.2,0.5088), (48.32,0.4561), (52.6,0.364), (57.19,0.2763), (64,0.24), (73.5,0.19), (91.3,0.125), (100,0)))$	
Adopters from recharge infrastructure	$\text{Recharge infrastructure density effect} * \text{Potential adopters per year}$	Person
factor recharge infrastructure	0.04	
Total adopters from Recharge Infrastructure	$\text{factor recharge infrastructure} * \text{Adopters from recharge infrastructure}$	Person
Contact rate	$\text{Potential Adopters} / \text{Adopters}$	
Adoption fraction	0.01	
Total population	1.028×10^7	Person
Adopters from Word of Mouth	$\text{Total population} / \text{Contact rate} * \text{Adoption fraction}$	Person
Actual driving range	$WITH\ LOOKUP\ (Time, ((0,0)-(20,400)), (0,400), (5,300), (10,50), (20,2)))$	min
Recharge time effect	$WITH\ LOOKUP\ (Actual\ recharge\ time, ((0,0)-(500,1)), (0,1), (5,0.93), (60,0.38), (85,0.23), (120,0.1), (160,0.06), (350,0.01), (500,0)))$	
Adopters from Recharge time	$\text{Recharge time effect} * \text{Potential adopters per year}$	Person
factor recharge time	0.06	
Total adopters from Recharge Time	$\text{factor recharge time} * \text{Adopters from Recharge time}$	Person

Table 2: Model Summary — variables and functions



6 Results and Discussion

In this chapter are presented some scenarios and tests with extreme value changes to better understand how the market could evolve in the near future and is also very useful to detect flaws in the model.

6.1 Basic scenario

The basic scenario is based on the values explained throughout section 5. Figure 8a shows an exponential growth of the population of adopters, characterized by a slow but steady growth in the beginning (year 2020-2027), and a large growth in the end (year 2028- 2040). In figure 8b can also be seen the adoption rate with an exponential behavior, especially in the first 15 years. Both results are obviously connected, by the model definition, and this exponential growth is due to the fact that, as seen earlier, most of the factors are in the acceptable conditions "imposed" by the customers after the first 10 years, meaning that after those 10 years (in 2030) the consumers start more easily and frequently purchasing electric vehicles, hence, the exponential growth.

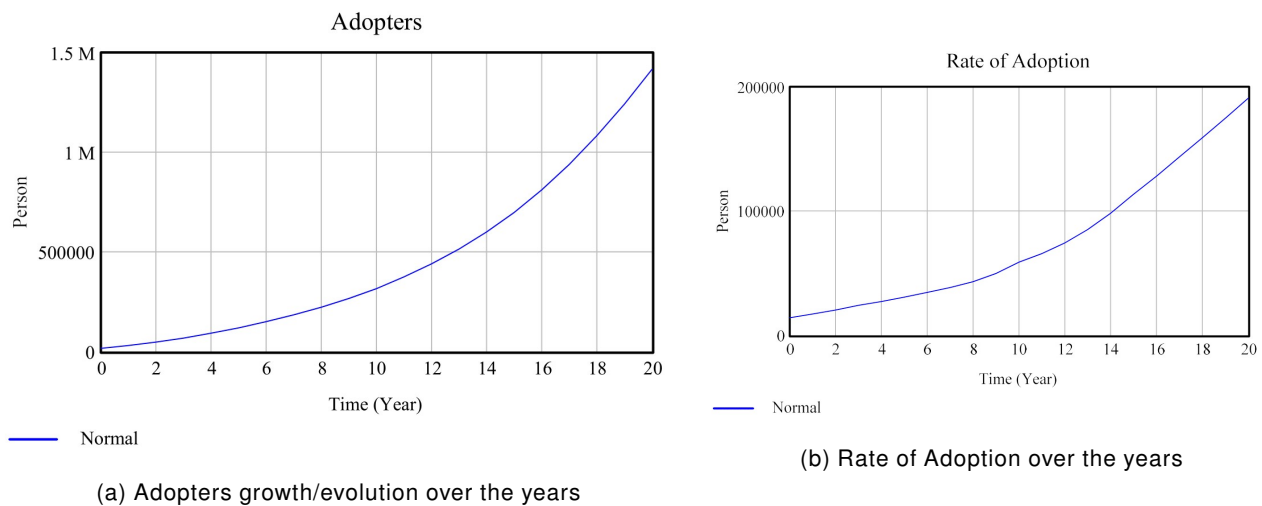


Figure 8: Graphical representation of basic scenario results

6.2 Scenario Situations

Scenario situations use the same values for the model as in the basic situation except from the variable that is being tested or changed to simulate a particular scenario and are useful to create insights for the model and to make the assumptions more reliable.

6.2.1 Price Difference Effect

The price difference between an EV and an ICV is the most crucial factor that keeps potential adopters from purchasing an EV. According to the surveys and the information portrayed in section 5, the area around a zero (or negative) price difference has the most effect on the adopters. In contrast to others factors such as driving range, the price difference can be "artificially" influenced through subsidies given by the government. Therefore the subsidy scenario is given in a situation where the government would provide a subsidy of 5000€ on the vehicle fixed price from 2020 to 2029, that is, the first 9 years.

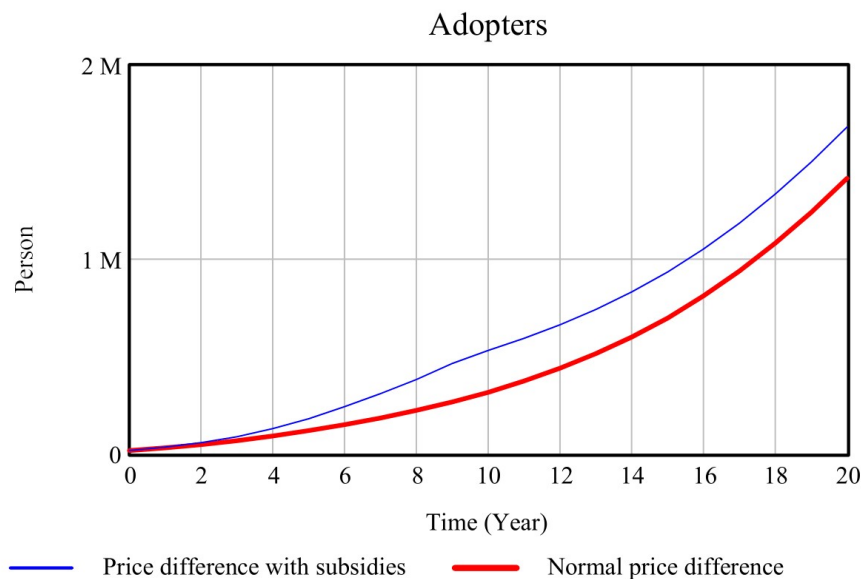


Figure 9: Adopters Growth in function of Price Difference variations

Figure 9 shows the result of the scenario described above. As we can see in the graph, the subsidy allowance was effective in the sense that in the first 9 years, the adoption rate clearly increased because in the same time-frame the scenario with the subsidies had a bigger growth of adopters than the basic one. After those 9 years, the adoption rate decreases a little and approximates to the adoption rate of the basic scenario. This "boost" on the first 9 years was able to positively influence the EV market as we ended the 20-year time-frame with considerably more EV adopters in the altered scenario when compared to the basic one.

6.2.2 Infrastructure Network Density and Recharge Time Effect

In this section, the study focuses on the infrastructure network density and the recharge time effects on the EV market.

In this verification, there 3 different scenarios: **the normal one**, **the scenario with a high density infrastructure and slow charging times** and one last **scenario with a high density infrastructure and fast charging capabilities**. The normal one is the basic scenario referenced earlier.

The other two scenarios have a high density recharging network, meaning that we have total coverage on Portuguese territory from the start (year 2020). The graph of the actual recharge network density in these scenarios has a similar appearance/behaviour than the normal one, being the only difference the starting value that in these scenario has a value of density of 10km, instead of 100km.

There are two scenario's given, the first encompasses an early (year 2010) total coverage of a slow (8 hours) and a fast (30 min) recharge infrastructure with a density of 10 km. Secondly, an extremely fast (5 min) and slow (8 hours) recharge time is simulated with use of the estimated infrastructure as defined in chapter 4 and 5. This extremely fast charging scenario represents the battery switch technology which indicates that recharging is replaced by switching the battery within 5 min. The time range is set to 10 years, because this better shows the effect of the infrastructure and recharging times in the early phase of the adoption process.



What sets these two scenarios apart is the charging times, in one of them, we have slow charging capabilities (with a initial value of 8 hours) and in the other we have fast charging capabilities (with a initial value of 30 minutes).

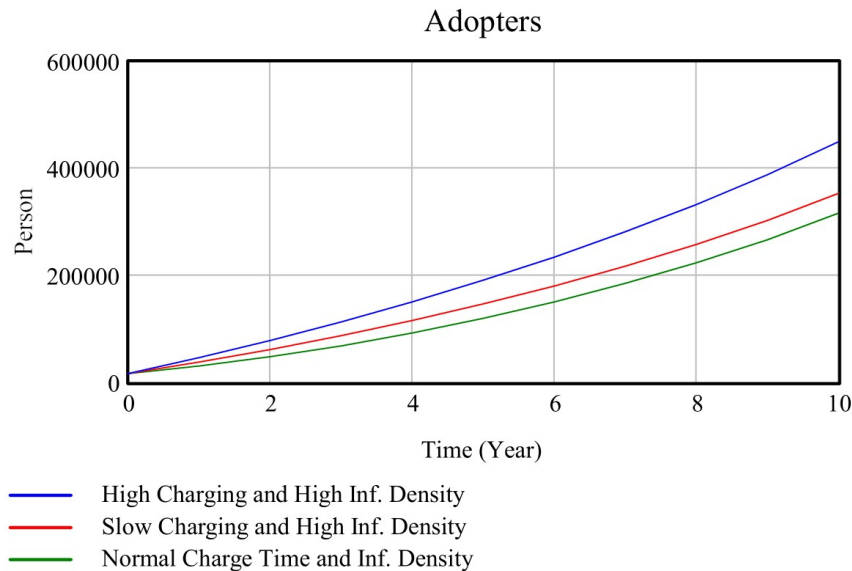


Figure 10: Adopters Growth in function of Infrastructure Density and Charging Time variations

Figure 10 shows the result of the scenario described above. As we can see in the graph, these scenario simulations allows us to conclude that the population of adopters increases as result of both **high infrastructure density** and a **fast charging capabilities**. As we can see, the scenario with high recharge infrastructure density and slow charging is still able to "produce" more adopters than the basic scenario. This is related with the premised stated earlier that a high density recharge network allows for slower charging times, because there is high availability of charging stations. The optimal scenario is when we have a high density charging infrastructure and fast charging capabilities from the start, being these two conditions the best of both worlds. However, a optimistic yet feasible scenario is to have a high density charging network in the early stages of EV introduction (first 10-15 years) and then focusing on improve the charging times of the already existent EV charging stations.



7 Conclusions

From what was possible to understand from this study, it can be concluded that when we are dealing with a market research study, consumers' input and opinion is crucial to accurately grasp and understand the importance of multiple factors and their relationships in the respective market.

Furthermore, considering the model described in section 5 and its respective results, detailed in section 6, it is clear that, despite the current limited capabilities of the underlying technology and the restricted technological evolution of Electric Vehicles, the growth of the EV market, regarding its population of adopters has an exponential behaviour, leading to the belief that, at some point in the future, the personal vehicles market will be dominated by EVs.

Moreover, it also reasonable to conclude that a major factor to help accelerate the purchase of EVs and promote its further development is the government subsidies, being the price one of the greatest obstacles to consumers when considering to buy an EV. The other obstacle to current EV adoption is the driving range of these vehicles, that is quite limited in current models, however, the implementation of a well distributed recharging infrastructure with optimal coverage is key to minimize this factor and mitigate the existent doubt of transportation viability with an EV.



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