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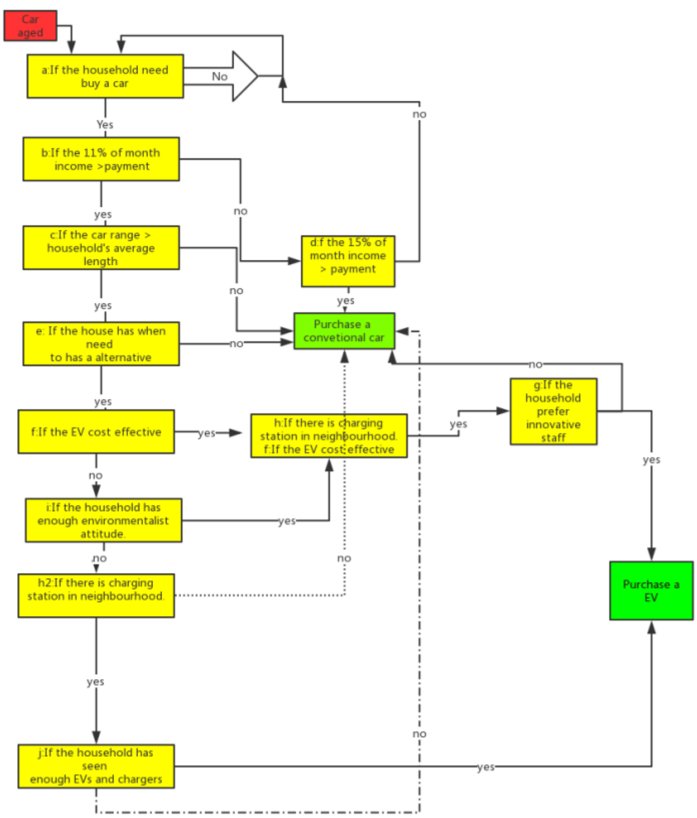
Exploring technological breakthrough influence on the adoption of EVs

Introduction

As people pay more attention to climate warming, energy security, and sustainability, the influence of electric vehicles (EV) is even more obvious (Krause etc. 2015). Besides, it is an important strategy for most countries and organizations to develop electricity as fossil energy alternatives. In some special application scenarios, such as airport shuttle buses, metro-buses, trams and official fleet, electric vehicles have a relatively high penetration rate. These scenarios are often ordered in large quantities, and the daily driving route is fixed, so fixed and user-friendly charging equipment can be configured. This does not affect the user experience (Sullivan, etc. 2009). However, in the global market, the market adoption of electric vehicles has not reached breakthrough growth. Its market share is generally maintained at around from 2% to 5%, and the market growth rate gradually decreases after the market dividend (Rogers. 2003). Chris etc. (2016) observed under the ideal conditions, the combination of multiple policies will stimulate the market share of electric vehicles to reach 10% in the next 20 years according to agent-based models. According to the study of Chris, the investment on EVs' policy intervention is enormous, and the effectiveness not very significant. In addition, with the breakthrough of artificial intelligence, automated production technology, 3D printing, and battery technology, the performance and design of the electric vehicle itself are likely to transform dramatically in recent years. In fact, the industry does not have a consensus on the future development trend of electric vehicles. Therefore, this article attempts to use ABM modeling to explore the impact of technological breakthroughs on the market share of electric vehicles.



Modeling

Figure1: The process

As for purchase behavior, it involves two aspects, first is the actual value of the car, followed by the social value of the purchase behavior, and Rogers (2003) believes that social values such as innovative preference, environmental-friendly concepts, herd behavior and other theories have a significant impact on the purchase of electric vehicles. Individuals associate the purchase behavior with their

Word count: 980

unique attributes and it is a process of interaction with other individuals and the environment (Figure1). Therefore, the ABM will simulate each family' purchase of vehicles. Variables settings and model configurations are given in the OOD. Due to the complexity of the model, some of the parameters that reflect the environment, such as the average income, income standard deviation, car purchase ratio, etc., are to be input by the users according to the research object, in order to improve the flexibility and applicability of the model. This paper applies this model to a new and small town -- Yuzuiin New District, Chongqing, China. According to the "Statistical Bureau of Chongqing" (2011) and Teng's (2012) paper on electric vehicle development, the input variables are shown in Table 1 and the town is represented in Figure2.

Name of Parameters	Value	EV-price	$28000	Charging patter	C (randomly in the district)
Maximum-mileage	185(Km)	Charger price	$1100	Price - electricity	$0.25 / km
Average income	$2500	Population	5000	Price-different	50%
Income standard error	1400	Initial cars	1000	Price - gasoil	$0.3 / km

Table1: The parameters in Yuzui Town

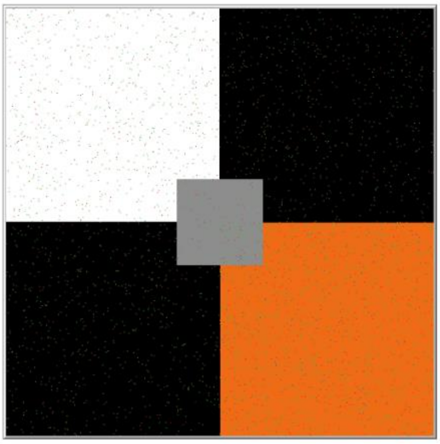


Figure2: The Yuzui Town.

Teng's (2012) paper claimed that the EV's maximum mileage is too short, the price is too high, and the price gap between EVs and the traditional car are the three main defects of electric vehicles. Therefore, this paper sets the scenario A: the maximum mileage is greatly improved; B: The price of conventional cars and EVs is reduced by 50%; C: The price gap between conventional cars and EVs owning the same performance is greatly reduced. Changes in the three scenarios compared with Table 1 are shown in Tables 2. Due to the limitation that the model runs too slow, each scenario just run 15 times repeatedly and it runs for 60 steps each time that represents 5 years.

Scenarios	Transformation
A	Change maximum mileage to 350KM
B	Change EV-price to $18000 and conventional cars' price decrease proportionally.

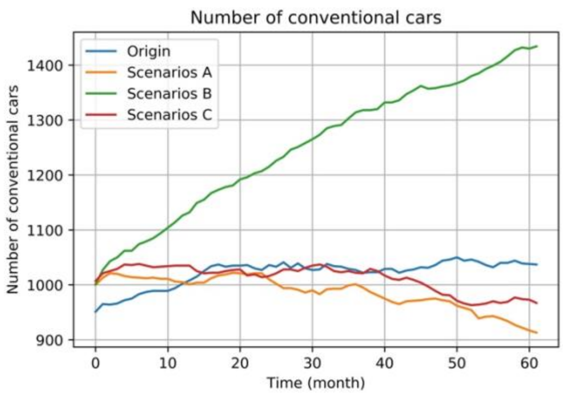
Word count: 980

C	Change price difference 0.05

Table2: The parameters' changes in Scenarios A, B and C

Results and analysis :

After 15-times repeats, the average of conventional cars and EVs in the four scenarios are shown in Figure 3 and Figure4 (the following data is all the average of all repeats). Figure3 and 4 illustrate that the three scenarios all increase the adoption of EVs as the B also increase the usage of conventional cars dramatically. More important, the inflection point in figure4 reflect there will be some fluctuation due to the aging of vehicles and the periodicity. Overall, the price impact most on the adoption of EVs, followed by the decrease of the price' s gap. In addition, except for decreasing the price of all vehicles, other breakthroughs of EV' s technology can occupy some conventional cars' market. In 5 years, the share of EVs reaches over 35% in scenario A.



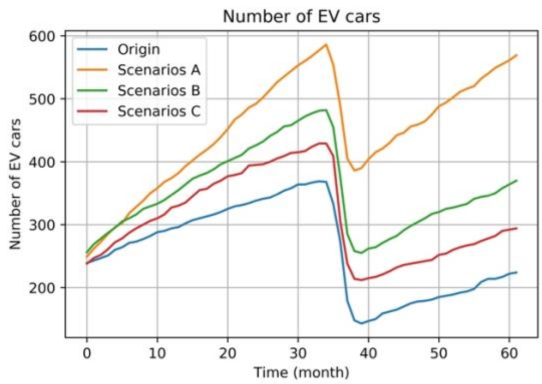
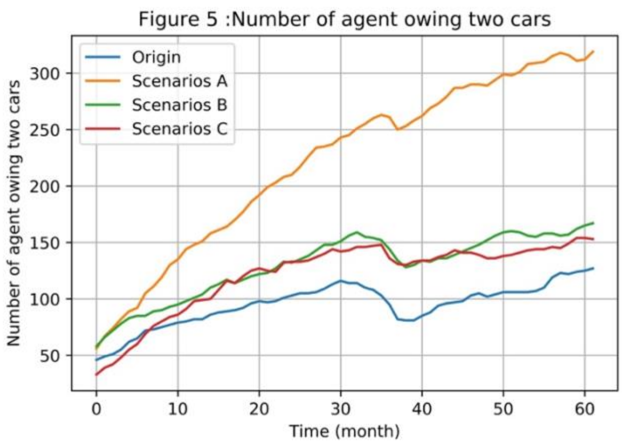
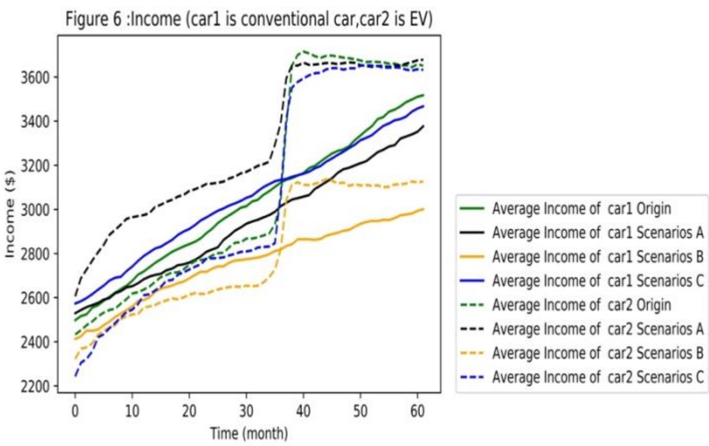


Figure3: The number of conventional cars   Figure4: The number of EVs

Figure 5 illustrates that the three transformations all increase the probability of owing two cars, among them, the increase of maximum mileage will make people owning two cars two times than other scenarios.





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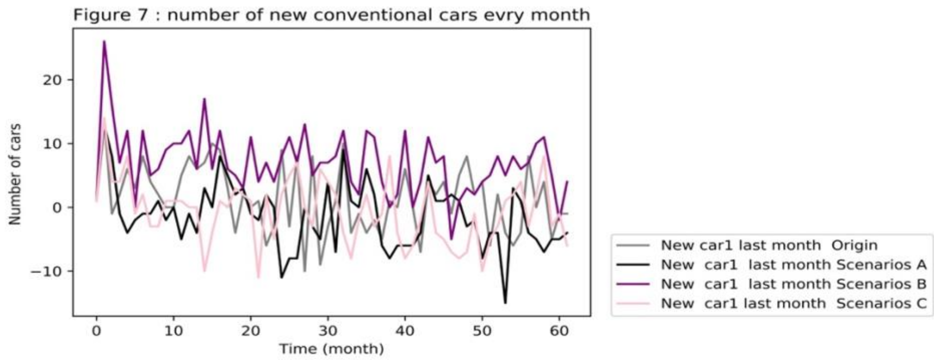
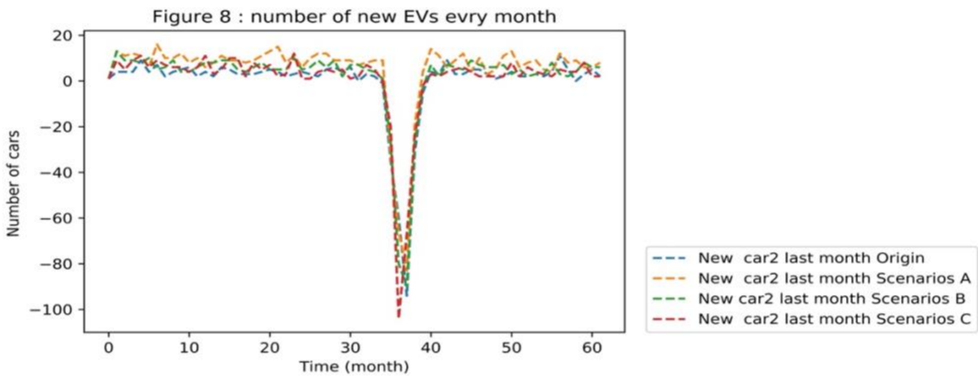
It is clear in Figure6 that the average of EV-owners' income is lower than the conventional cars', and the inflection and why the average income of conventional cars' buyers keep increasing is not clear. By comparison, the income of EVs' buyers reaches steady at a point.

Figure7 and 8 give the change of conventional cars and EVs in every month, the monthly change of conventional cars shows similar fluctuation in all scenarios with little difference. However, the situation of EVs is meeting a great fall in around 3 three years from the beginning, which is also reflected in Figure 4.





Conclusion

According to the results, in Yuzui town, extending the maximum mileage can improve the EVs' adoption significantly, which is not sure to be true in other places with different conditions. However, the model can be applied in other situations by varying parameters. In addition, the general decrease of vehicles' price can dramatically increase the purchase of conventional cars accompanied by a relatively slight growth of EV's share. The periodicity of EVS should be taken into account planning infrastructure and designing new products.

The model runs too slow (50 seconds a step) and its parameters are hard to be explicit are two main defeats that are eager to be fixed in the next step.

Word count: 980

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