EMPIRICAL ANALYSIS OF THE DEPRECIATION OF ELECTRIC VEHICLES COMPARED TO GASOLINE VEHICLES

Lukas Schloter, Technical University Munich, +49 175 3188942, lukas.schloter@tum.de

Overview

Climate change is urging industries worldwide to shift their business model to more sustainability. This trend has a particularly strong impact on the automotive industry as greenhouse gases from road transportation contribute to 17% of global emissions. For many years, the automotive industry has been facing disruptive changes of their business model by growing digitalization, new forms of mobility and strengthening focus on sustainability. In particular the latter can be seen in the increased need to electrify their fleet. The electrification of passenger cars is one of the most dominant challenges for the automotive industry also triggered by increasing regulatory pressure by many nations worldwide. The regulatory support together with the increased sustainable awareness of consumers has resulted in increased number of new registrations of electric vehicles (EV) in many developed countries. Norway has been the forerunner in new registrations of EVs since many years with a share of 74% in 2020, but also other European countries have lately been catching up such as Germany (13%). The different technical setup of EVs compared to conventional vehicles with a large battery and a much smaller electric engine implies changes in the cost structure of the EV compared to conventional vehicles. The battery makes up the largest portion with roughly 40% of the total production costs. The experience with the mass production of EVs is roughly only a decade, resulting in limited but growing knowledge about the degradation and life expectancy of the battery. This lack of knowledge impacts also the view on the depreciation of EVs. While there is a lot of data on the historical depreciation of conventional vehicles, little is known of the value loss of EVs. The depreciation of vehicles is an important economic indicator for many stakeholders: Car manufacturers need the depreciation and life expectancy of their cars to estimate costs for guarantee. Banks determine the conditions of car credits based on the depreciation of the car. Authorities require the deprecation to define subsidies or taxes. Lastly, also consumers have a high interest to understand the value development of their investment.

Methods

I selected five key automotive markets (Germany, USA, Norway, Sweden, the Netherlands) for my analysis. All of the selected countries have EVs on the road and an established second hand market since many years. I chose electric and gasoline vehicles along several vehicle segments from premium as well as mass market makes. The focus is solely on online platforms as data source to gather as many entries as possible. I used leading regional online platforms e.g., autoscout24.com for Germany and the Netherlands, bytbil.com for Sweden, finn.no for Norway and edmunds.com for the USA. To get a high amount of data entries, I developed a Python script which automatically gathered the required vehicle data from the websites. The price on the website is in general the offered price by the dealer and not the actual transaction price of the deal. However, as the difference should be marginal, I am interested in the delta to conventional vehicles with the same offered price and I will index the price for comparison, the offered price is sufficient for the analysis. I collected a total of over 40,000 car price data entries in the years 2020 and 2021. Afterwards, I cleaned up the data for entries with insufficient and inaccurate data and excluded vehicles with high deviations in price and mileage as well as cars with damages resulting in a total of 24,325 data entries. The manufacturer suggested retail price (MSRP) of the vehicles is in general not available on the online platforms. For this reason, I collected the exact vehicle model from the online platforms and collected the MSRP from other data sources such as the car manufacturer websites. As I would like to understand the influence of vehicle characteristics such as age or mileage on the value of the vehicle, I applied a multiple linear regression analysis. The regression analysis is based on the equation developed by Linz et al. (2003) for their analysis of the price development of used vehicles in Germany:

$$ln(R_i) = \beta_0 + \beta_1 \cdot \frac{M_i}{A_i} + \beta_2 \cdot A_i + \beta_3 \cdot ln(S_i) + \delta_1 \cdot D_{make(1)} + ... + \delta_8 \cdot D_{make(8)} + \epsilon_i \qquad (1)$$

where R is the (resale) value of vehicle i, M is the total mileage driven of vehicle i, A is the age in months of vehicle i, S is the MSRP of vehicle i, $\beta_0,...,\beta_3$ are the coefficients of the predicting variable, D is the binary dummy variable of a make, $\delta_1,...,\delta_8$ are the coefficients of this predicting variables D and ϵ is the standard error of vehicle i.

The logarithmic relationship of the value of the vehicle and the MSRP are based on the observation of the vehicle data and the relative mileage has been used to prevent a multicollinearity between total mileage and age of the vehicle.

Results

I performed a regression analysis on the full sample of 24,325 entries by applying equation 1. I separately analyzed electric and gasoline vehicles to compare the influence of the predicting variables between the two propulsion types. Table 1 reports the results of the regression analysis. The results show that the coefficients β_0, β_1, β_2 and β_3 are significant by a value of >99%. Additionally, the results of the regression show that the used variables in the regression function have a good regression fit which is indicated by the high R_2 value of 0.902 and 0.925. Due to the logarithmic transformation, the depreciation of the vehicles as a variable of age is defined by $e^{\beta 2-1} \approx \beta_2$. As for the numerical values of β_2 the approximation gives an error per month of roughly 0.5%, I decided to use the exact formula. Thus, I calculated the annual depreciation of the vehicle based on age by applying the equation $e^{\beta 2 \cdot 12}$. This results in an age-dependent annual depreciation of EVs of 13.1% and of gasoline vehicles of 9.9% excluding the impact of the other predicting variables such as MSRP or relative mileage. Fig. 1 is the graphical representation of the value development of a reference vehicle in relationship to the age. The MSRP of the reference vehicle is set to 40,000 EUR, the relative mileage per month to 1,500 km and the reference make is BMW. On the y-axis I divided the value of the vehicle by the MSRP to obtain the relative value of the vehicle. I observe that the EV has at point zero already a value below 100% with 88%. This observation can be explained by the definition of the MSRP in the data. The manufacturer suggested retail price excludes the local subsidies which exist in the analyzed countries. Thus, the line representing EVs is shifted downwards. To address this phenomenon, I set the value of the EV in the starting point to the same value of the gasoline vehicle. Afterwards, I applied the depreciation on the plot (dashed blue line). For this indexed depreciation line I observe that EVs have a higher depreciation compared to gasoline vehicles. Based on the regression function, I see that a gasoline vehicle with the reference vehicle specifications has after 5 years a value of 56% compared to an EV with only 47%.

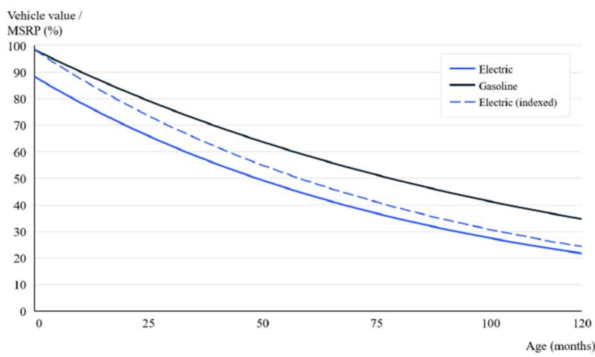

Figure 1: Value decline of a gasoline and electric vehicle by age

Furthermore, I observe a degressive development of the value. For the reference vehicle characteristics, I see a monthly depreciation of gasoline vehicles of 0.87% (10.4% per annum) and EVs of 1.16% (13.9% per annum).

Conclusions

I analyzed over 24,000 used vehicle entries and conducted a regression analysis to describe the influence of predicting variables such as age or MSRP on the value of vehicles. The data reveals a degressive depreciation of vehicles over their age. The conducted regression analysis shows a high significance for the predicting variables age, MSRP, relative mileage and vehicle make and validates similar regression result conducted by Linz et al. (2003). The results show that vehicle age has the highest impact on the value of vehicles. When applying characteristics of a typical reference vehicle, I observe a depreciation over the vehicle age of 0.87% per month (10.4% per annum) for gasoline and 1.16% per month (13.9% per annum) for EVs. The observed depreciation can be confirmed by similar values conducted in different approaches by Linz et al. (2003) and Guo et al. (2019). Furthermore, I see in the direct comparison of the two propulsion types that EVs have a higher depreciation rate over the vehicle age compared to gasoline vehicles. The rationale behind this deviation is not part of this research, but might be in the faster technological advancements of EVs, the still decent demand or the uncertainties about the battery degradation and life expectancy. That might change with increasing market penetration of EVs in the future resulting in the depreciation shifting closer to that of gasoline vehicles. For research on the economics of vehicles as well as for other stakeholders such as financial institutions, car manufacturers or governments, the results mean that different depreciation rates have to be considered for EVs compared to conventional vehicles. The applied equation 1 can be used for a good approximation to calculate the value of a vehicle.