Competing technologies in the car market: a nested multinomial logit approach

Sylvia Bleker, VU University

Electric vehicles (EV’s) are making a comeback. Governments give out subsidies, practically all car firms offer an electric variant and EV sales grow each year. However, sales still lag behind expectation, since prices of EV’s are still too high. The literature offers many reasons for the high price.

First of all, production cost is higher than that of standard cars with internal combustion engines (ICV’s). The technology of EV cars is relatively new compared to ICV’s and materials used in EV’s are more expensive. The battery is the main determinant of high cost of EV’s. Also, battery packs are heavy, therefore the rest of the car has to be made of lighter and more expensive material.

Aside from the production cost, range anxiety contributes to a price that is too high for consumers. Consumers are not familiar with EV technology. Batteries have lower range than gasoline tanks and recharging stations are not as ubiquitous as gasoline stations. These factors contribute to range anxiety and a lower willingness to pay for EV’s. For example, according to the study by Dimitropoulos et al. (2013) EV price should be around half the price it is now, to be competitive with ICV’s.

In this paper we offer another possible explanation of price that is too high, namely industry structure. Currently, both traditional ICV firms as well as new specialized entrants produce EV’s. This paper asks if it matters, in terms of prices and EV demand, whether EV’s are offered by traditional firms or new entrants. Additionally, we compare welfare over the different scenario’s and offer insights for regulatory agencies.

To do this analysis, we compare the equilibrium outcomes in different industry structures. We present a standard nested multinomial logit model (NMMNL) with three nests. A nest for ICV variants, another nest with EV variants and a nest which holds the outside option (a generalized measure of using other transport modes). The price of the outside good is exogenously set, while the prices of the car variants are determined by firms optimizing profit. We fix the amount of variants that are sold in the market, there are three ICV variants and one EV variant. These numbers are chosen to model the real world in which substantially less EV models are offered compared to ICV models, while keeping the total number of variants offered small to keep analysis tractable. Then, we find equilibrium outcomes when different numbers of firms produce these variants. Ranging from a monopolist which sells all car variants, to the situation where there are four firms each selling one variant. This gives us a total of seven possible different industry configurations, given the four variants. We compare EV sales and welfare measures between each of the seven possible industry structures and rank the structures accordingly.
The model is applied with competition between EV technology and ICV technology in mind, but is very general and can be applied to any industry that is adequately described by the NMNL model. Thus, the results do not only help us understand EV competition, but also give us insights into the NMNL model. While many articles have been written on the NMNL, not many articles look at asymmetric equilibria. Specifically, equilibria where firms can have products in multiple nests and firms are allowed to be of a different size (sell different amounts of variants). Asymmetric solutions are mostly not discussed, because asymmetric equilibria are generally not analytically solvable. In this paper we present an analytical implicit equilibrium solution for mark-up. Explicit analytical solutions are not possible, but we will present numerical results. Our model thus offers new insights into the workings of the NMNL with asymmetric firms.

The implicit analytical solution for the profit mark-up takes the form of an adjusted Lerner-index. It shows us that, as in the standard Lerner-index, profit margin is a function of the negative inverse of the demand elasticity. However, the formula has an added term that is positive if a firm sells products in more than one nest. Thus, offering products in multiple nests leads to a higher profit margin.

The numerical analysis shows that market structures where the EV variant is sold by a specialized firm, as opposed to a firm also selling ICV products, leads to higher EV sales in total. Thus, to promote EV sales, specialized EV firms should be subsidized over traditional firms also selling ICV cars. This result is robust to parameter changes.

The rankings based on consumer surplus and profit stay the same as parameters change. Thus, depending on whether a country is a car importer or exporter (and thus favors consumer surplus or industry profit) it is straightforward for competition authorities to decide which industry structure would be best for the country. However, it is not so straightforward to make predictions on the best market structure in terms of total welfare.

Competition agencies usually use the Herfindahl index to make a prediction in terms of whether one or another industry structure will be best. We show that in this case, the Herfindahl index is not a reliable index. We also present an adjusted Herfindahl-index, that better represents the characteristics of our current model. However, both indices are not successful in predicting total welfare. A lower concentration in terms of the Herfindahl-index does not necessarily mean a higher welfare. However, we will present another statistic that is reliable in this regard. Competition agencies can use this information to, for example, analyze whether a proposed merger has a positive or negative effect on total welfare. This statistic does not depend on the parameters of the model and can thus be used regardless. It relies on prices, marginal cost and on demand for each product. In case no reliable data on marginal cost is available, it is also possible to simply compare average price in the different industry structures. This also leads to a prediction that is more reliable than the Herfindahl-index.
Our model makes a start in analyzing how industry structure affects total demand for EV’s. Moreover, it can be applied to any market which is sufficiently described by the NMNL model and offers new insights into the workings of the NMNL model with asymmetric firms. Finally, it presents a simple statistic which competition agencies can use in, for example, merger analysis to analyze the effect of different industry structures on total welfare.

**A selection of key references**


