IS THE FOURTH INDUSTRIAL REVOLUTION LEADING THE WORLD TO THE BRINK OF A NEW CLIMATE HYPER-CRISIS WITH ELECTRICAL VEHICLES?

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ABSTRACT

Based on historic evidence related to technology developments that arise into the society with the promise of cutting-edge energy-efficient goods and the puisne consequences the present paper intends to evaluate the Electric Vehicles new demand as a new technology intended to displaced the ICE and determine if a new raw material market arises with the Co2 footprint of this industry and the links with the fossil fuel derivates (Xing et al., 2019). The methodology (cross-price elasticities of demand) intends to evaluate consistently all the data and evidence in order to determine if, besides the main benefits of the massive use and implementation of BEV, the impact of this new industry will cause a non-reversible effect in humanity as once was caused by the gasoline even when at that time they were provided with enough proofs relating its poisonous with several humans deceases. Nowadays the relation is given the current world industry infrastructure and its emissions/contamination can beard a new industry demand that will duplicate (or more) the raw materials demand in case of the BEV end-up as a complementary good. Exist from the governments committed and involved in this new industry clear guidelines to determine the most accurate and responsible extraction of raw materials and production from developed countries.

Keywords: Battery Electric Vehicle; Internal Combustion Engine; Demand Cross Elasticity; Climate Change; Substitute Goods, Raw Materials, Mining, Co2 Footprint.

1. INTRODUCTION

The thesis of this paper is to determine if BEV are more likely to be a complementary good for the fossil fuel vehicles (FFV) in which case the reduction of the production and consequently the sales of fossil fuel vehicles will not be showing a drastic reduction, therefore the impact over the GHG emissions and the climate change will not be as expected. In this scenario, it will need to evaluate in deep the global policies and evaluate actuarially the impact of the new production of EV due to the world will be in a new production scheme where the demand of vehicles is compound by the total sum of BEV demanded units plus the total sum of FFVs demanded units increasing with this the demand of raw materials and petroleum derivates (Lasse Fridstrøm, 2018). This is a big concern due exist large evidence of the levels of contamination in the transformation process of the raw materials but also in the extraction process which includes deforestation and contamination of the nearest water sources, also air pollution and a human component of exploitation of the manpower.

An analysis of the current raw materials suppliers will provide a big picture of how much will increase the demand according to the EVs sales projections up to 2030 and the effect this may cause in the countries with the most of the mines which in the most of the cases are developing countries. Even more in the particular case of EV, a huge tread is arising linked with the batteries technology based in the lithium and the biggest reserves of this mineral (Notter et al., 2010a). According to the International Energy Agency, the demand for lithium will increase 42 times by 2040 (Energy Agency, 2021). In this aspect, Latin America is a key player by being the main source of raw materials and one important source of petroleum, but also for being the home of the most important ecosystems and sweet water sources of the world. Just in terms of lithium, the main world reserves in million tons (t / a) are Bolivia (21), Argentina, (19.3), Chile (9.6), Australia, (6.4), China (5.1), Canada (2.9), Germany (2.7), Mexico (1.7) (USGS, 2021).

In terms of global emissions, no matter the level of emissions of the BEV the GHG will be increased by the creation of a new industry boosted by demand for a new and complementary good as it may be BEV. On the other hand, if the datasets demonstrate BEV are a substitute good for FFV this will reinforce the accuracy of the current industry trend and will have a positive effect on the GHG reduction. This will be achieved by discouraging the FFV demand and will be evidenced by a reduction in the production and sales levels.

LITERATURE REVIEW

The goal of this literature review is to evaluate three different approaches to the emissions problem evaluation in the EV market and their associated incidence of exploitation of raw materials and petroleum derivates which the suppliers are mostly based in developing countries from LAC. Using a Cross-Price Elasticity of the Demand Function Lasse Fridstrøm and Vegard Østli and Jianwei Xing, Benjamin Leard, and Shanjun Li described the phenomenon of technology displacement/replacement, reporting signs of great substitution on ICE with an EV in the vehicles market by clean emerging technologies. Anna Stamp, Dominic Notter, Hans-Jörg Althaus, Marcel Gauch, Patrick Wäger, Rainer Zah, and Rolf Widmer makes a great contribution in the general understanding of the environmental impacts of the BEV production as a frequent problem in the GHG emissions by describing a methodology based in the Ecoindicator to measure the damage caused by the battery industry demand of copper and aluminium for the production of the anode and the cathode (Notter et al., 2010b). Troy R. Hawkins, Bhawna Singh, Guillaume Majeau-Bettez, Anders Hammer Strømman states that the overall rate found on EVs powered by electricity in the European Union offer a 10% to 24% decrease in global warming potential (GWP) relative to conventional ICE vehicles (Hawkins et al., 2013).

2. METHODS

The main purpose of the vehicles is transportation, no matter the power source. Thus, if the technology is BEV or ICE doesn't affect the end-user perception of the utility of the vehicle. In the case of both technologies, they will achieve "almost" the same performance. The cross-price elasticity of demand will show the relationship between ICE and BEV, by capturing the responsiveness of the demanded quantities of one vehicle technology to a change in the price of another vehicle technology. The fact that one ICE is substitutable for BEV has immediate economic consequences: insofar as one can be substituted for another, the demands for the two vehicles will be interrelated by the fact that customers can trade off one vehicle for the other if it becomes advantageous to do so. An increase in the price of a vehicle x will (ceteris paribus) increase demand for its substitutes, while a decrease in the price of goods, will decrease demand for its substitutes (Curtis & Irvine, 2017).

Price dynamics: To build up the demand function curve the information is arranged according to the methodology. In this first step, the approach is to determine the responsiveness in the period 2016-2021. As the information for 2021 is not complete the analysis is elaborated with data from the Q3 of 2021. The vehicles ICE and BEV datasets were collected in 2016 Q3 and 2020 Q3 (*GCBC*, 2021).

Brand	Model	# 16	Price 16	# 20	Price 21
Nissan	Versa	132,214	10,600	48,272	14,930
Volkswagen	Golf	13,764	18,000	21,927	23,195
Chevy	Spark	35,511	16,660	33,480	13,400
Mitsubishi	Mirage	26,966	16,000	19,135	16,490
		52,113	**15,315**	**30,703**	**17,003**

Figure 1 Prices for ICE 2016-2021

For each brand is calculated the mean of both datasets, price and sold units for both years, 2016 and 2020[1]*.

$$\sum_{1}^{\infty} P_1 = \frac{P_{16}(Nice + Vice + Cice + Mice)}{n} \qquad \sum_{1}^{\infty} Q_1 = \frac{Q_{16}(Nice + Vice + Cice + Mice)}{n} \qquad \sum_{1}^{\infty} P_2 = \frac{P_{21}(Nice + Vice + Cice + Mice)}{n} \qquad \sum_{1}^{\infty} Q_2 = \frac{P_{21}(Nice + Vice + Cice + Mice)}{n}$$

ICE Demand Curve 2016-2021: In the year 2016, the market reaches a mean of 52,113 units of vehicles from the sample with a mean price of $ 15,315 per unit. This price increase to $ 17,003 per unit, seems to cause a reduction in the units sold by 2020 which drops to 30,073 units. The prices of the selected brands and models expose a reduction in the number of sold units in five years: $\Delta Q = q_2 - q_1 =$ - 21,410 units. A total reduction in sales of 21,410. Despite the reduction in terms of sold units, the price had a positive variation: $\Delta P = p_2 - p_1 = 1{,}698\ USD$. This variation means that the final price of the selected brands and models experimented with a mean increase of USD 1,698 per unit. Therefore, a new curve of demand is expected to appear providing the accurate level of Q units of vehicles at the price that consumers were willing to pay before losing payment capacity of 1,698 USD in the last 5 years.

Brand	Model	# 16	Price 16	# 21	Price 21
Nissan	Leaf	14,006	34,200	9,559	31,620
Volkswagen	e-Golf	2,482	28,995	19,044	36,720
Chevy	Spark	7,400	25,510	7400	26,000
Mitsubishi	i-MiEV	94	22,995	94	20,700
		5,995	27,925	9,024	28,760

Figure 2 Prices for BEV 2016-2021

For each brand is calculated the mean of both datasets, price and sold units for both years, 2016 and 2020*. In the year 2016, the market reaches a mean of 5,995 units of vehicles from the sample with a mean price of USD 27,925 per unit. This price increases up to $ 28,760 per unit, seems to be a good not sensitive with the price or is a market which in terms of technology update is willing to pay the new price: $\Delta Q = q_2 - q_1 =$ 3,029 units. A total increase in sales of 3,029. Despite the increase in the price: $\Delta P = p_2 - p_1 = 835\ USD$. This variation means that the final price of the selected brands and models experimented with a mean increase of USD 835 per unit, in this case, a new curve of demand is *not* expected due to the willingness of the customers with a new price rising.

Cross-Price Elasticity of Demand Function ICE-BEV: In this case, the cross-price elasticity may be a positive or negative value, depending on whether the vehicles are complements or substitutes. If ICE-BEVise complements, an increase in demand for one is accompanied by an increase in the quantity demanded of the other. Therefore, the value of the cross-price elasticity for complementary goods will thus be negative. The output from the cross-price analysis is 0,887 which determines a positive slope. This also means ICE is not a complimentary good for BEV.

[1] Data from 2020 Q3

$$\varepsilon_{ICE,BEV} = \frac{\%Q\Delta\, ICE}{\%\Delta\$\, BEV} = \frac{\frac{30{,}703}{52{,}113}}{\frac{5{,}995}{9{,}024}} = \frac{0{,}589}{0{,}664} = 0{,}887$$

Electrical Vehicles Vs. Fuel Based Vehicles Demand: A cross-price Elasticity of the Demand Function on the BEV-ICE up to the year 2030 Pin terms of price and sales projections will be performed. The method proposed to evaluate the price of the vehicles in 2030 and determine its future price is to select a base brand and model which meet that both brand and model still in the market from 2016 to 2020 and have in the same line of the vehicle the option for ICE and BEV. In this regard, the selected brand is the manufacturer Hyundai with the representative model for ICE "Azera" and the representative model for BEV "Ioniq":

$$\varepsilon_{ICE,BEV} = \frac{\%Q\Delta\, BEV}{\%\Delta\$\, ICE} = \frac{\left(\frac{5{,}995}{9{,}024}\right)}{\left(\frac{30{,}703}{52{,}113}\right)} = \frac{0{,}664}{0{,}589} = 1.12$$

Sales extraction from Deloitte: The data relating to the sales projection will be extracted from the Passenger Global Car Sales study developed by Deloitte in 2017.

ICE sales in 2016: 90.000.000 units.

BEV sales in 2016:100.000 units.

ICE sales in 2030: 85.000.000 units.

BEV sales in 2030:18.00.000 units.

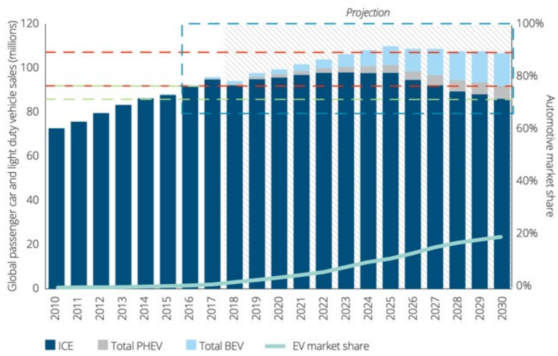

Figure 3 Passenger Global Car Sales Deloitte in 2017

Vehicles Price Projection: To get a basis for calculating the projections up to 2030 due to the lack of price projections in the vehicles market, we suggest using the same price variation evidenced in the period 2016-2020 and estimate under the same percentage the variation for 2030. This implies applying the same step 2,25 times, due to the period analysed comprehends four years and the period to analyse is of nine years. Calculating the price variation α 2016-2020 for Hyundai Azera: $\%\Delta\alpha = p_{2-}\, p_1 \therefore \frac{\%\Delta}{p_2} = 0.14$. Calculating the price variation β 2016-2020 for Hyundai Ioniq: $\%\Delta\beta = p_{2-}\, p_1 \therefore \frac{\%\Delta}{p_2} = 0.12$.

	2016	2020
Hyundai Azera	$ 24,186	$28,150
Hyundai Ioniq	$ 28.834	$33,045

Reversing prices for 2030 and substituting with the price variations.

Brand	Model	# 16	Price 16	# 30	Price 30
Hyundai	Azera	90.000.000	24,186	85.000.000	31,620
Hyundai	Ioniq	100.000	28,834	18.000.000	33,045

Cross-Price Elasticity of the Demand Function BEV-ICE 2030

$$\varepsilon_{ICE,BEV} = \frac{\%Q\Delta\, BEV}{\%\Delta\$\, ICE} = \frac{\left(\frac{18.000.000}{100.000}\right)}{\left(\frac{31{,}620}{24{,}186}\right)} = \frac{180}{1.307} = 137{,}7$$

3. EXPECTED RESULTS

3.1. *Electrical Vehicles Vs. Fuel Based Vehicles Demand.:* The outcomes of the is expected to state according to with the trends in the industry and market that BEV is not a substitutive good, therefore, is a complimentary good which explains the projections in the vehicle industry with an increase in the trends of production.

3.2. *Electrical Vehicles/ Electrical Vehicles Batteries – Raw Materials Demand:* (ongoing) This may be caused by a new industry incumbent which will create additional stress in the raw materials demand with all negative effects summarized in an increase of the Co2 emissions. To determine the impact, the projections of the BEV will be calculated according to the projections of the future raw material demand up to 2030. An analysis from the raw materials derivates from petroleum will be tackle as well.

4. DISCUSSION

In the present research, not intend to evaluate the impact of PHEV- HFCV or evaluate this technology as EV due to the complexity of the data at the moment of determining which amount of the energy came from clean sources and how much the owners use the electric option instead of the combustion engine also to not analyse the impact on the GHG by the power sources for BEV and the energy sources like thermoelectrical plants powered by nuclear-atomic energy and fossil fuels as petroleum, diesel and coal. It is also important to mention that ICE includes not just fossil fuel but hydrogen as well. In this regard worth mentioning that the impact of HFCV corresponds to less than 1% of the market shares. A last restriction in the research scope does not include the pollution and Co2 emissions related to the infrastructure both to provide the energy supply and for the extraction and manufacturing process.

5. CONCLUSION

The Cross-Price Elasticity of the Demand Function ICE-BEV in all cases end up with positive results, which also means positive slopes. Despite the present findings, the results are not determinants due to the inner character of the emergent market of BEV, the accuracy of the databases and the lack of evaluation of different methodologies to project values and quantities in the future. The result from this research is intended to turn into a new scientific insight that provides trustable information related to the transition from ICE to BEV as the main driver in the race against climate change. This will allow policymakers to determine if investing in BEV infrastructure or other technologies like electric trains, cable cars or other electric transport technology.

AUTHOR CONTRIBUTIONS

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Full paper Cross Elasticity Methodology