E-mobility in Indian Automobile Sector: Graffiti of a New Challenge

- D.Mazumdar[1] & Mainak Bhattacharjee[2]

I. Introduction

Sustainable development is one of the most important issues of development dynamics in today's world.

The Sustainable Development Goals (SDG) of the UN, in its 7th Goal, has emphasized affordable and cleaner energy. It has indicated that energy is the dominant contributor to climate change, accounting for around 60 per cent of global greenhouse gas emissions. The objective of gradual transition of fossil-fuel operated motor vehicles to battery-operated electronic motor vehicles (where the energy is produced mainly from the alternative and renewable sources of energy) can be set in this backdrop. Thus, as any technological transformation helps any country to a gradual shift from the traditional fossil-fuel operated motor vehicles to the energy-saving modern electronic vehicles (EVs), such an e-mobility can definitely generate a positive externality in production and help the country in achieving the SDG. However, in this transition process, a less developed or developing country can face some infrastructural and resource constraints which can lead to an increase in user charges to such an extent that the benefit might be concentrated within few people, at least during the short run. This shows the challenge before the new technology in relation to e-mobility in the automobile sector. In this paper, our objective is to build a model that captures this challenge and also help the planners to identify the factors which are to be taken into account to overcome the future constraints in this transition process.

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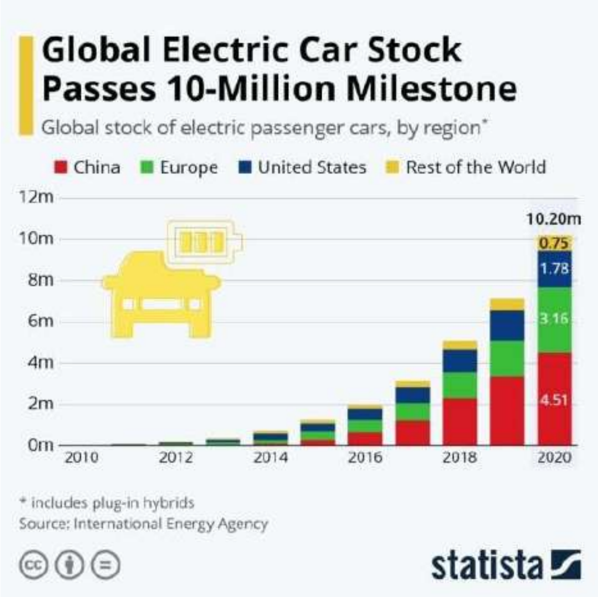
1. Professor & HOD, Dept. of Economics, The Heritage College Kolkata
2. Assistant Professor, Dept. of Economics, Loreto College, Kolkata

II. World scenario

Despite 2020 being a sluggish year for the global automobile industry, electric car sales continued to grow. According to the latest edition of the International Energy Agency's Global EV (Electronic Vehicle) Outlook, electric passenger car sales climbed despite the total automobile industry contracted by about 16 per cent. While Europe overtook China to become the world's largest EV market for the first time in 2020, China still had the largest number of electric cars on its roads with a total stock of 4.5 million in 2019.

As evident from Fig.-1, the past decade has been one of rapid growth for electric cars, even though we are still at the beginning of the transition to cleaner and more sustainable mobility (viz. an e-mobility). Despite the fact that the number of electric passenger cars in use increased globally from close to zero in 2010 to about 10.2 million in 2020, electric cars and plug-in hybrids (which use both fossil fuel as well as rechargeable batteries)accounted for only 4.6 per cent of the global passenger car sales in 2019.

Fig.-1 Growth Trend in Global Stock of EV (Passenger cars) during 210-2020 (includes plug-in hybrids)



Source: International Energy Agency (2020)

A record three million electric cars were registered globally in 2020, 41 per cent higher than in 2019. That trend has continued in2021 also with 2.5 times as many registrations recorded as during the same period last year.

The growth (as shown in Fig.-1) is being driven by strong sales in Europe and China with 450,000 and 500,000 EVs sold, respectively. The United States has also experienced a doubling of its sales during January-March, 2021 compared to the first quarter of 2020. In 2020, customers throughout the globe spent $120 billion on electric car purchases and governments supporting them with $14 billion in subsidies, a 25 per cent increase in 2019. This was driven by strong incentives in Europe that have seen the continent as the world's largest EV market for the first time as opposed to that of China so far.

III. Scenario in India

By pushing electric mobility under the Faster Adoption and Manufacturing of (Hybrid and) Electric Vehicles Phase-II or FAME-II scheme and setting an ambitious target of generating 175 gigawatts of power from renewable energy by 2022, India has made clear its intent to reduce greenhouse gas emissions. It is to be noted that transport accounts for about 11 per cent of India's carbon emissions. The government's target is to ensure that at least 15% of the vehicles in the country would be electric vehicles by 2030 and this is aimed at reducing vehicular pollution and dependence on crude oil imports. According to an estimate given by the Council of Energy, Environment and Water (Delhi), apart from environmental gains, this transition or e-mobility is likely to save crude oil imports worth Rs 1,07,566 crore for India,

The rapid adoption of EVs, however, will also mean an increase in the consumption of lithium-ion batteries, viz., rechargeable batteries used in a number of industries (including automotive and consumer electronics) and the subsequent rise in the number of spent batteries that would require environmentally sound end-of-life handling. These batteries are chiefly made up of lithium, cobalt, nickel, iron, copper and aluminium. The life of an EV battery ranges between six and eight years and needs replacement when its capacity starts falling below 80 per cent. Batteries are stacked together in cells and modules to make a battery pack. Once these batteries begin losing their capacity, they can be managed in two ways: either they can be repurposed for secondary applications or they can be sent for recycling directly and metals can be recovered from them using a particular technology.

According to the information provided by the Society of Manufacturers of Electric Vehicles in India, currently, there are nearly 2.5 lacs EVs on the road that uses lithium-ion batteries in India. Among them, two-wheelers account for 80 per cent or about 2 lac vehicles, three-wheelers comprise nearly 25,000-30,000 and the rest are four-wheelers.

Table-1 Probable EV Penetration in India

Segment	Sub-Segment	EV Penetration (%)	
		2025	2030
2-wheeler	Scooters	15-25%	50-70%
	Motorcycles	1-2%	10-20%
	Overall	7-10%	25-35%
3-wheeler	Overall	35-45%	65-75%
4-wheeler (light)	Personal	1-3%	10-15%
	Commercial	5-10%	20-30%
Bus	State Transport Undertakings	15-25%	25-40%

Source: Economic Times, NOV 4, 2020

According to a report titled 'Shifting Gears' prepared by KPMG and CII in 2019, the light mobility segments of 2/3-wheelers and commercial cars will be leading EV penetration in India by 2030. The reach of electric cars in the personal mobility segment will be only

10%-15%. However, electric cars for ride-sharing and taxis may see traction of 20%-30%.By the end of this decade, the three-wheeler adoption is expected to be around 65%-70%. Electric two-wheelers, with a plethora of startups offering different ranges of products at an attractive price and ownership models, are expected to have only 25%-35% penetration. The probable penetration of EVs in different segments of the automobile industry has been shown in Table-1.

Their prices and fuel economy make them commercially more viable. In a recent (2020) global survey made by Statista (USA), it has been observed that fuel efficiency has been the top priority for the new car owners (Fig.-2). Fig.-2 reveals that 66 per cent of the new car owners emphasize on fuel efficiency aspect of the new car. From this viewpoint, there remains a favourable market for EVs. However, this pattern seems to be more true for the European market compared to that of India. At present, we observe an oligopolistic market structure in the automobile sector with the existence of few car manufacturers dominating the entire market. In the EV segment (4 wheelers) also the manufacturers such as Tata Motors (EV segment: Tata Tigor, Tata Nexon), Mahindra & Mahindra (EV segment: E Verito & E20 Plus), Maruti Suzuki (EV segment: Wagon R EV), MG Motors (EV segment: MG ZS), Hyundai (EV segment: Kona electric), etc. have created an oligopoly market structure. More interestingly, the product price in this EV segment ranges between Rs. 8 lacs to 16 lacs for the EV varieties produced by Tata Motors, Mahindra & Mahindra and Maruti Suzuki, i.e. these are affordable for the consumers who presently purchase petrol/ diesel versions. However, this price soars up to Rs 1 crore and more for EVs produced by Jaguar or Mercedes Benz. In the 2/3 wheelers segment also, the companies like Hero Motors, Revolt Motors, Mayuri (e-rickshaw), Ather energy, Retrosa (Avera scooter) etc. are producing EVs. Despite such positive elements in the business environment, such an e-mobility faces some crucial challenges at the present moment in India.

Fig.-2 Preference pattern of the New Car Owners

Source: Statista Global Consumer Survey, 2020

IV. Constraints in the process of e-mobility

India's phased manufacturing plans of EVs in several segments of the automobile industry are likely to face some challenges. These challenges or constraints include (i) the absence of adequate reserves of key raw materials like lithium and cobalt, (ii) inadequate expansion of industries that manufacture lithium-ion batteries, (iii) inadequate charging infrastructure (viz. the charging points spread throughout the country) for facilitating the owners of EVs, (iv) inadequacy of power supply based on the non-renewable sources of energy, and (v) the absence of a well structured local supply chain.
Owing to the paucity of mineral resources used in making lithium-ion batteries, India mostly imports lithium-ion cells and batteries, though some companies are assembling batteries from imported cells.

The supremacy of China in this field can be easily shown by its comparative advantage in the production of some of the primary inputs required for the production of EVs. According to the statistical information provided by Benchmark Mineral Intelligence (a London-based research firm for the lithium-ion battery industry), Chinese chemical companies accounted for about 80 per cent of the world's total output of raw materials (viz. lithium) for advanced batteries in

2019, and out of the proposed 136 lithium-ion battery plants to be established in the world within 2029, 101 are based in China. Further, In addition to rare earth, the manufacturing of lithium-ion batteries depends also on some key materials like graphite (the material used in pencil tips), and it is observed that China produced more than 60 per cent of the world's graphite in 2019. So far as cobalt is concerned, another very useful and important ingredient for the production of EVs, the Democratic Republic of the Congo (DRC) produces more than 60% of the world's mined cobalt. However, a recent working paper published by the OECD shows that 8 out of the 14 largest cobalt mines in the DRC are Chinese-owned and account for almost half of the cobalt output of DRC.

In the case of the 2/3 wheelers segment, the unorganized and small players are dominating in India due to the limited scale of business. In order to combat this, the NITI Aayog is laying a key role in setting up EV chargers. In 2020, there were about 270 units of installed EV chargers in India. NITI Aayog has partnered with NTPC to set up 100,000 EV charging stations across India. Other government entities like BHEL have partnered with ISRO to develop batteries using Lithium technologies.

As we have already stated, most of our lithium requirements are currently imported from China, South Korea, Vietnam, Singapore, and Japan. Several players who have shown interest in the Lithium battery production business in India include Reliance, Suzuki, Toshiba, Denso Corp, JSW Group, Adani, Mahindra, Hero Electric, Panasonic, Exide Batteries, etc. This is a good sign. However, most of the experts in the Indian automobile industry are of the view that the sluggish trend in the Indian automobile market since March-April 2020 can be a significant obstacle towards the process of e-mobility in this industry. In addition, the steps taken to enable the acceptance of EVs will not suit their main purpose if alternative means of electricity production are not implemented. Currently, up to 60% of the electricity is produced from coal. Although the government has set major aims to bolster the growth of EVs a lot more has to be done to ensure they are implemented.

At the end of March 2018, thermal power plants accounted for an overwhelming 69.25 per cent of the total installed capacity in the country, with an installed capacity of 2,76,293 MW. However, if we won't move ahead towards achieving the goal of sustainable development then non-renewable energy sources are to be tapped more efficiently. The total installed capacity of grid-interactive renewable power, as per the government report, was about 57,244 MW in March 2017, and this had gone up to about 73,352 MW in October 2018 indicating a growth of 28% during the period. Out of the total installed generation capacity of renewable power in October 2018, wind power accounted for about 47.7%, followed by solar power including rooftops (33.1%) and biomass power (13.0%). Karnataka had the highest installed capacity of grid-connected renewable power (12,933 MW) followed by Tamil Nadu (11899 MW) and Maharashtra (8780 MW), mainly on account of wind and solar power. More such efforts are to be taken on the part of the government to expand and utilize this potentiality. Otherwise, the objective of e-mobility in the automobile sector cannot be materialized properly.

V. A Theoretical Model

To address the current dispensation, a general equilibrium model has been conceived herein. The model mimics a small open economy with three sectors, namely, the traditional automobile manufacturing sector (X), a modern automobile sector producing vehicles powered by electricity(Y) and another sector producing non-automobile manufacturing (Z). All three sectors use a fixed coefficient production technology as what is represented by a Leontief type production function. Now, the inputs which are being used in these sectors can be classified as skilled labour (L_s) used in X and Y, a specific capital (K_1) in Y and capital (K) in X and Z. In the ranking, skill-intensive sector Y comes first followed by X and Z. On the other hand, sector X is relatively K-intensive compared to sector Z All the sectors are assumed to have a competitive industrial structure such that each firm in each sector earns a normal profit. Each sector is open to foreign trade with sector Y being import-competing in nature, while

X and Z are exporting in nature. Further, it has been supposed that sector Y and sector X are relatively dependent on clean energy while the Z is relatively dependent on dirty energy. Moreover, the factors are fully employed. As against this backdrop, we have the following structural equations:

$$P_X = a_{SX}W_S + a_{KX}r \ldots\ldots\ldots\ldots\ldots (1)$$

$$P_Y = a_{SY}W_S + a_{KY}r_1 \ldots\ldots\ldots\ldots\ldots (2)$$

$$P_Z = a_{SZ}W_S + a_{KZ}r \ldots\ldots\ldots\ldots\ldots (3)$$

Where $a_{ij}\, a_{ij}$ denotes the per the unit requirement of input 'i' in sector 'j'.

$L_s(1-\alpha) = a_{SX}X + a_{SY}Y + a_{SZ}Z \; L_s(1-\alpha) = a_{SX}X + a_{SY}Y + a_{SZ}Z \ldots\ldots\ldots\ldots\ldots$ (4)

[where Ls is fixed supply of skilled labour and 'α' is the depreciation rate of their productivity due to vehicular emission (E), i.e. α= α(E), where α′ > 0].

$$K_1 = a_{KY}Y \ldots\ldots\ldots\ldots\ldots (5)$$

$$K = a_{KX}X + a_{KZ}Z \ldots\ldots\ldots (6)$$

[Note: all factor supplies are exogenously given]

Now in this model, the endogenous variables are factor prices, namely, $W_S W_S, r_1 r_1, r\, r$ and final output of the three sectors, X, Y and Z. Similarly, there are six equations to solve these six endogenous variables.

Impact of increase in emission on the economy:

Herein we shall examine the exogenous increase in emission on the outputs of the sectors. To this end, we shall have a comparative static exercise on the output-subsystem[as indicated in equations (4) to (6)] to have the following developments.

$$L_S\alpha_0\varepsilon_{\alpha}^{E}\hat{E} = \beta_{SX}\hat{X} + \beta_{SY}\hat{Y} + \beta_{SZ}\hat{Z} \ldots\ldots\ldots (7)$$

$0 = \beta_{K1,Y}\hat{Y} \dots \dots \dots (8)$

$0 = \beta_{KX}\hat{X} + \beta_{KZ}\hat{Z} \dots \dots \dots (9)$

[Note:$\varepsilon_\alpha^E \varepsilon_\alpha^E$ stands for the emission elasticity of rate of depreciation of skilled labour]
Solving the aforementioned equations, we get:

$$\hat{X} = \left[\frac{L_S\alpha_0(\varepsilon_\alpha^E)\beta_{KZ}}{\beta_{SX}\beta_{KZ} + \beta_{SZ}\beta_{KX}}\right]\hat{E} \dots \dots . (10)$$

$$\hat{Y} = 0 \dots \dots \dots (11)$$

$$\hat{Z} = \frac{\beta_{KX}}{\beta_{KZ}}\left[\frac{L_S\alpha_0(\varepsilon_\alpha^E)\beta_{KZ}}{\beta_{SX}\beta_{KZ} + \beta_{SZ}\beta_{KX}}\right]\hat{E} \dots \dots . (12)$$

Therefore, for $\hat{E} > 0\ \hat{E} > 0$, we get $\hat{X}, \hat{Z} < 0\hat{X}, \hat{Z} < 0$ since, $\varepsilon_\alpha^E < 0\varepsilon_\alpha^E < 0$. Thus we have the following proposition.

Proposition1: Increase in emission results in the contraction of output of the exporting sectors, led by the contraction of productivity and therefore may have adverse macroeconomic implications and at the same time can potentially call for a switch to electric vehicles.

Impact of change in policy-induced vehicular life span for operation:

This pertains to the measure taken by the government to reduce the operating span of Tovehicles powered by non-renewable and polluting fuel, like petrol and diesel. This would require replacing the traditional automobiles more frequently than before and thereby will help boost the production of the traditional vehicle through demand boost. Now, let this operational span be denoted by θ and so much so that X is increasing in θ. The reason being that the increased demand for the traditional vehicle due to more frequent replacement will cause an increase in its price and, hence, trigger a rise in its supply depending upon the degree of elasticity. Moreover, the increase in supply may be associated with the increased import of auto-parts and that, particularly in absence of indigenous unavailability may produce adverse effect on the external sector in terms of increased trade deficit. However, such adverse effect can be countered depending on the export augmenting the capacity of X. Herein we shall take resort comparative static exercise on the output sub-system of the overall model to determine the consequence of such policy. The result is as follows.

$$\hat{X} = \left(\frac{1}{\theta_0}\right)\left(\varepsilon_X^{\theta}\right)\hat{\theta} > 0 \ldots\ldots\ldots\ldots(13)$$

$$\hat{Z} = -\left(\frac{\beta_{SX}}{\beta_{SZ}}\right)\left(\frac{1}{\theta_0}\right)\left(\varepsilon_X^{\theta}\right)\hat{\theta} < 0 \ldots\ldots\ldots\ldots(14)$$

Proposition 2: Expansion of the automobile sector due to altered replacement norms enforced by the government comes at the cost of contraction of non-automobile manufacturing. This fallout can be overcome through an increase in the supply of skilled labour and capital (by attracting FDI).

Impact of FDI in manufacturing of electric vehicle:

Herein, we shall examine the consequence of foreign capital inflow towards the manufacturing of electric vehicles using comparative statics. This implies an increase in K_1 and the result of which is as follows.

$$\hat{Y} = \frac{\widehat{K_1}}{\beta_{K1,Y}} > 0 \ldots\ldots\ldots\ldots(15)$$

$$\hat{X} = \frac{\left(-\frac{\beta_{SY}}{\beta_{KX}}\right)\left(\frac{\widehat{K_1}}{\beta_{K1,Y}}\right)}{\left(\frac{\beta_{SX}}{\beta_{KX}} - \frac{\beta_{SZ}}{\beta_{KZ}}\right)} > 0[Since\ X\ is\ K - intensive\ relatively\ to\ Z] \dots\dots\dots\dots\dots (16)$$

$$\hat{Z} = \left(\frac{-\beta_{KX}}{\beta_{KZ}}\right)\hat{X} < 0 \dots\dots\dots\dots\dots (17)$$

Proposotion3: FDI inflow into the modern automobile sector proves to be propitious for the expansion of traditional one due to the operation of the factors like technological spill-over, leading to the enhancement of factor productivity by and by and subsequently, an improvement in fuel efficiency quality. However, such development goes against the merit of non-automobile manufacturing, which however can be averted through comprehensive FDI policy boosting foreign capital inflow into Z (i.e., increase in K as well).

VI. Conclusion

Thus, efforts at ushering in technological transition in an automobile through the introduction of electricity-powered vehicles have their pros and cons. On the one hand, it helps in lowering carbon emission and thereby prevents the erosion of quality human capital along with enabling technological spill-over into the traditional automobile sector. On the other hand, it may fail to auger well for the non-automobile manufacturing due to the dearth of capital and labour resources for which a comprehensive development policy stressing the human-capital formation and foreign capital inflow with the transfer of state-of-art technology is warranted.

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> Creativity is seeing the same thing but thinking differently
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> - APJ Abdul Kalam