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THE E-VEHICLE INDUSTRY IN INDIA: A POLICY ANALYSIS

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ABSTRACT

Given the need for environmental sustainability, it is important for the Indian governments; central and state, to work on establishing the industry for electric vehicles. Currently, to meet set targets, subsidies and fee concessions to investors and purchasers are largely being relied on. However, policymakers need to analyse further the supply and demand side variables that would lead to an active market. This paper overviews the situation in India for industry layout and demand along with the current constraints on the government. It then provides a game theoretic framework for the EV market, showing how a desired equilibrium can be strategically achieved. It further provides a contrast with China's case and the impacts of an EV shift.

Keywords: *electric vehicle, ICE vehicle, infrastructure, environmental stability, strategy*

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1. INTRODUCTION

Vehicular emissions have been at the forefront of environmental issues and make countries bear heavy costs due to health impacts, climatic offsets and subsequent impacts on economic activity. India, being the second most populous country in the world, incurs major costs and faces high risks of worsening pollution in the future. It is the third largest emitter of greenhouse gases in the world. 87% of India's CO2 equivalent emissions of the transport sector come from road transport. Still, India has roughly 11 cars per 1000 people, compared to 403 cars per 1000 people in the United States [1]. This lower proportion implies that the need for sustaining economic growth makes it unfeasible for most states of India to curb vehicular activity. Hence, the shift to Electric Vehicles becomes particularly necessary. Electric car deployment has been growing rapidly over the past ten years, with the global stock of electric passenger cars passing 5 million in 2018, an increase of 63% from the previous year [2]. In FY2019, total EV sales in India were over 7, 50,000 and reached a total of 7, 59,600 units. This includes electric two-wheelers (1, 26,000), electric three-wheelers (6, 30,000) and electric passenger vehicles (3,600), which implied electric two-wheelers witnessing growth of 130 percent year-on-year. Despite this, India has less than 1% of the Electric four wheelers' share globally. The required progress in the EV market to deal with

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pollution is therefore much greater. Both the Central and several state governments have realized the importance of a shift in the country from Internal Combustion Engine Vehicles to Electricity Powered Vehicles or Electric Vehicles (EVs). Several governments have set targets of achieving goals of complete and partial transition to Electric Vehicles in the public and private transport sector [3]. Measures largely consist of subsidizing purchases for consumers and improving the "ease of doing business" for potential firms by reducing charges for set-up. Tax concessions and smoothening of the registration processes have been initiated by several state governments. Moreover, ease in land procurement has also been highlighted. The Union Budget of 2019 incorporated major tax breaks for Lithium ion and other manufacturing plants [4] to boost the supply-side.

However, it is important to note other crucial factors that determine the participation of firms and generation of demand. If the business environment, with respect to these other factors, is not conducive enough, then the current government policies will not be successful in causing market growth.

2. INDUSTRY LAY-OUT

2.1 Lithium-Ion Battery Production

It has been largely established that a sizeable market for Electric Vehicles, especially as a replacement for ICE vehicles, requires large scale production of the key components of these products. Here, it is identified that the lithium-ion batteries that are the best alternative for EVs currently must be made easily accessible in the EV industry in India which makes the plans for internal production of vital importance.

2.2 Production Aims

India has committed to cutting its GHG emissions intensity by 33% to 35% percent below 2005 levels by 2030. India proposes to add 175 GW of renewable energy capacity by 2020 and to achieve 40 percent of its electricity generation from non-fossil sources by the same year [4]. It is given that each GWh (1,000-megawatt hour) of battery capacity is sufficient to power 1 million homes for an hour and around 30,000 electric cars [4]. It is highly desirable for this policy objective of the government to be achieved. For the same, plans involve the set-up of Giga factories for lithium-ion batteries in the country similar to those in the United States. It is necessary to analyse the intricacies in setting up such a plant.

2.3 Production Giga-plants: Tesla Comparison

For analysing the nature of investment in production, we consider the case of the establishment of the Giga plants emulating those of Tesla Inc. in Nevada, United States, which the Indian Government has decided upon. The Tesla Giga plant 1 is a venture carried out by three companies with their own divisions performing their own functions; Panasonic generating the battery cells and H&T manufacturing cell cans. Panasonic is the exclusive cell provider for Tesla and converts raw materials such as refined lithium and steel into the cells Tesla uses to create a Model 3 battery. Using a combination of human and robot labour, Tesla assembles the cells into long rows Lister calls “bandoliers,” because of the way the cells are arranged around a cooling tube. The tubes are also manufactured on-site by the company Valeo [5].

Qualified Project Name:	Gigafactory Project
Participant:	Tesla, Inc. (FKA: Tesla Motors, Inc.)
Reporting Period:	October 1, 2017 - December 31, 2017
Project to Date Period:	October 17, 2014 - December 31, 2017

	Reporting Period	Project to Date Period
Real Property		
Land	$ -	$ 41,989,595
Building/Structure	$ 22,991,171	$ 353,027,436
Building/Structure - CIP	$ 123,368,558	$ 1,232,222,395
Subtotal	$ 146,359,729	$ 1,627,239,426
Personal Property		
3- year life	$ 101,545	$ 1,069,639
5- year life	$ -	$ 14,384
7- year life	$ -	$ -
10- year life	$ -	$ -
15- year life	$ 3,208,327	$ 55,514,134
20- year life	$ -	$ -
30- year life	$ -	$ -
CIP - Life TBD	$ 116,168,388	$ 637,110,751
Other Property	$ -	$ 351,371
Expensed Property	$ 10,767,315	$ 29,734,810
Subtotal	$ 130,245,575	$ 723,795,089
Total Capital Investment	$ 276,605,304	$ 2,351,034,515

Fig. 1(a) Tesla Plant

Source: https://electrek.co/2018/08/21/tesla-gigafactory-1-3000-workers/

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Required Qualified Employee Audit Data

Qualified Project Name:	Gigafactory Project
Participant:	H&T Nevada, LLC
Reporting Period:	October 1, 2017 - December 31, 2017
Project to Date Period:	October 17, 2014 - December 31, 2017

Workforce Composition	Reporting Period	Project to Date Period
Number of New Qualified Employees (NQE)	27	93
Number of NQEs who are Nevada Residents	20	72
Residency as a Percent		77%
Average Wage of Qualified Employees		$ 33.26

Fig. 1(b) Tesla Plant

Source: https://electrek.co/2018/08/21/tesla-gigafactory-1-3000-workers/

Qualified Project Name:	Gigafactory Project
Participant:	Panasonic Energy Corporation of North America
Reporting Period:	October 1, 2017 - December 31, 2017
Project to Date Period:	October 17, 2014 - December 31, 2017

Workforce Composition	Reporting Period	Project to Date Period
Number of New Qualified Employees (NQE)	486	1,201
Number of NQEs who are Nevada Residents	473	1,182
Residency as a Percent		98%
Average Wage of Qualified Employees		$ 28.41

Fig. 2(a) Panasonic Plant

Source: https://electrek.co/2018/08/21/tesla-gigafactory-1-3000-workers/

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Qualified Project Name:	Gigafactory Project	
Participant:	Panasonic Energy Corporation of North America	
Reporting Period:	October 1, 2017 - December 31, 2017	
Project to Date Period:	October 17, 2014 - December 31, 2017	

	Reporting Period	Project to Date Period
Real Property		
Land	$ -	$ -
Building/Structure	$ -	$ -
Building/Structure - CIP	$ -	$ -
Subtotal	$ -	$ -
Personal Property		
3- year life	$ 35,562	$ 8,269,412
5- year life	$ -	$ -
7- year life	$ 27,972,458	$ 223,733,713
10- year life	$ -	$ -
15- year life	$ 17,695,037	$ 58,419,440
20- year life	$ -	$ -
30- year life	$ -	$ -
CIP - Life TBD	$ 125,652,352	$ 1,003,132,668
Other Property	$ -	$ -
Expensed Property	$ 505,101	$ 1,409,789
Subtotal	$ 171,860,510	$ 1,294,965,022
Total Capital Investment	$ 171,860,510	$ 1,294,965,022

Fig. 2(b) Panasonic Plant

Source: https://electrek.co/2018/08/21/tesla-gigafactory-1-3000-workers/

Qualified Project Name:	Gigafactory Project
Participant:	Panasonic Energy Corporation of North America
Reporting Period:	October 1, 2017 - December 31, 2017
Project to Date Period:	October 17, 2014 - December 31, 2017

Workforce Composition	Reporting Period	Project to Date Period
Number of New Qualified Employees (NQE)	486	1,201
Number of NQEs who are Nevada Residents	473	1,182
Residency as a Percent		98%
Average Wage of Qualified Employees		$ 28.41

Fig. 3(a) H &T Plant

Source: https://electrek.co/2018/08/21/tesla-gigafactory-1-3000-workers/

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Qualified Project Name:	**Gigafactory Project**
Participant:	**H&T Nevada, LLC**
Reporting Period:	**October 1, 2017 - December 31, 2017**
Project to Date Period:	**October 17, 2014 - December 31, 2017**

	Reporting Period	Project to Date Period
Real Property		
Land	$ -	$ -
Building/Structure	$ -	$ -
Building/Structure - CIP	$ -	$ -
Subtotal	$ -	$ -
Personal Property		
3- year life	$ 20,234	$ 122,334
5- year life	$ 31,940	$ 195,153
7- year life	$ -	$ -
10- year life	$ 5,206,154	$ 20,740,859
15- year life	$ -	$ -
20- year life	$ -	$ -
30- year life	$ -	$ -
CIP - Life TBD	$ 5,941,836	$ 56,727,876
Other Property	$ -	$ -
Expensed Property	$ -	$ -
Subtotal	$ 11,200,164	$ 77,786,222
Total Capital Investment	$ 11,200,164	$ 77,786,222

Fig. 3(b) H &T Plant

Source: https://electrek.co/2018/08/21/tesla-gigafactory-1-3000-workers/

The technological equipment used at the plant is not of a nature that is available in India, nor is the quality of Research and Development. Hence, there shall be need for heavy import of capital and knowledge requirements for the same purpose. The Indian Government has indicated an investment of $4 billion for this project while the cumulative value of the Tesla Giga factory 1 has been $5 billion [6]. Assuming here that the Government shall be generating private investment in this project worth over a billion dollars provides us a higher valued project in India; it is essential for the Indian plant to have higher aggregate investment as the availability of robotic and other highly advanced equipment as well as set-up infrastructure is understandably of a lower standard than that afforded by Tesla and Panasonic in the United States. What can be reasonably inferred is that the government will incur heavy short-term expenditure for this project.

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2.4 Tax Benefits: Nevada Comparison

The U.S. state of Nevada offered Tesla Inc. tax incentives worth $1.3 billion for building their facility. Alongside this, 20-year sales tax abatement worth approximately $725 million and property and business-tax abatements around $332 million and $195 million in transferable tax credits were also provided [7]. In this regard, the tax incentives offered by the Central Government of India, state governments and/or both have to exceed that provided in the former case as both the risk and cost of carrying out the same kind of project in India are higher than in the United States. So far, GoI is expected to offer 3% foreign exchange hedge on overseas loans and a fixed 3% interest subvention on loans availed in Indian rupees. In addition, a reduction in minimum alternative tax (MAT) may be offered [8]. These come alongside the reduction in Customs Duty to manufacture electric cells in India in 2021-2030, tax rebates up to Rs 1.5 lakh and total exemptions up to Rs 2.5 lakh and GST rate cuts on electric vehicles from 12% to 5% [6]. The comparison shows that tax incentives are required to be much larger in this context for successful implementation.

2.5 Local Employment Generation

Actual data provided by Tesla for June 30, 2018 shows 7,059 employees, which is 9 percent above projected employment levels for 2018. The count of qualified employees, as at June 30, 2018 was 4,247 [9]. Qualified employees are permanently employed individuals while unqualified are those who have not served a consecutive three-month term. The state government declared that the electric-car maker’s factory would add 4 percent to the gross domestic product of Nevada, where unemployment is 7.7 percent, the nation’s third highest. The cost of labour in India is relatively lower than in the U.S. due to lack of skill and large supply. Hence, the wages offered shall also be marginally lower here. I expect that to imply higher marginal product of labour which shall lead to greater employment for optimising the plant’s activity. I estimate the employment generation in the Indian state to be higher; at around 7,500. Labour substitution shall prove necessary in the relative absence of robotic technology. The high costs of availing said technology shall reduce its real marginal benefit although the efficiency in the case of greater labour usage shall be lower than when advanced equipment is used.

2.6 Foreign Collaborations

Tesla and China’s Contemporary Amperex Technology Co. Ltd (CATL) are among the companies that have shown an initial interest in the Indian government’s plan to build large factories to make lithium-ion batteries at an investment of about ₹50,000 crore. BYD Co. Ltd and Panasonic among others has shown interest in the same [6, 8]. It is feasible for India to take up projects as joint ventures with foreign collaborators at the Central as well as State level.

2.7 Lithium Resources

For successful functioning of the plants, an adequate supply of lithium carbonate and other requisite materials is extremely necessary. This is largely unavailable in India which is why there must be established trade connections for imports. Joint venture firms of the government are searching for the same. This is in the backdrop of Chinese state-owned firms securing lithium mine concessions in countries such as Bolivia, Argentina and Chile, which forms the so-called lithium triangle [6]. With Chinese acquisitions of lithium mines and concessions from countries not just in Latin America but also in Africa and other parts of the world have threatened the supply considerations for India in the EV manufacturing sector, especially as China is the most important rival in the market. Currently, 40% of EVs in India are imported from China; a reliance that must be rid of [8].

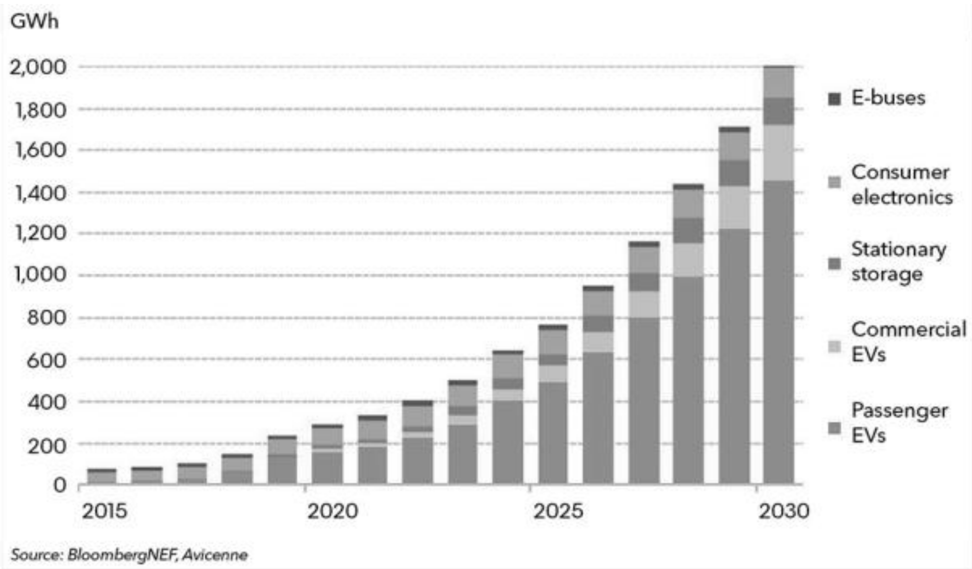

Fig. 4 Lithium Resources

Source: https://www.createai.io/blog/post/page/lithium-miners-news-for-the-month-of-may-2019

2.8 Recycling Infrastructure

With growing global demand for lithium-ion batteries and concentration of resources in a few parts of the world, the expected rise in the import costs of lithium, cobalt and other resources may prove damaging. In light of the same, it is necessary for India to take up the economic opportunity in developing the infrastructure for lithium-ion batteries, which, as per reports, offers a $1 billion industry in itself. These involve retaining the elements in the batteries and reusing them in the production process as well as carrying out second life recycling [10]. Current recycling methods, in the absence of policies and heavy Research investment, manage to generate 50% of the battery's previous economic value and the same can expectedly be made much larger in the future [10].

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2.8 Reliance on Imports

It is observable that India shall have major import bills with Lithium exporting countries, especially those in South America. However, due to recycling abilities, greater material durability as well as pre-established contracts with the countries, we can expect the same to be significantly lower than the current bills on oil imports. In this regard, we also find opportunity in extending exports to the concerned countries, especially since the lithium exporters are largely underdeveloped or developing and with resource revenue generation, shall have importing capabilities. Ties in this regard can prove to be highly beneficial.

2.9 Three Wheelers and Two Wheelers

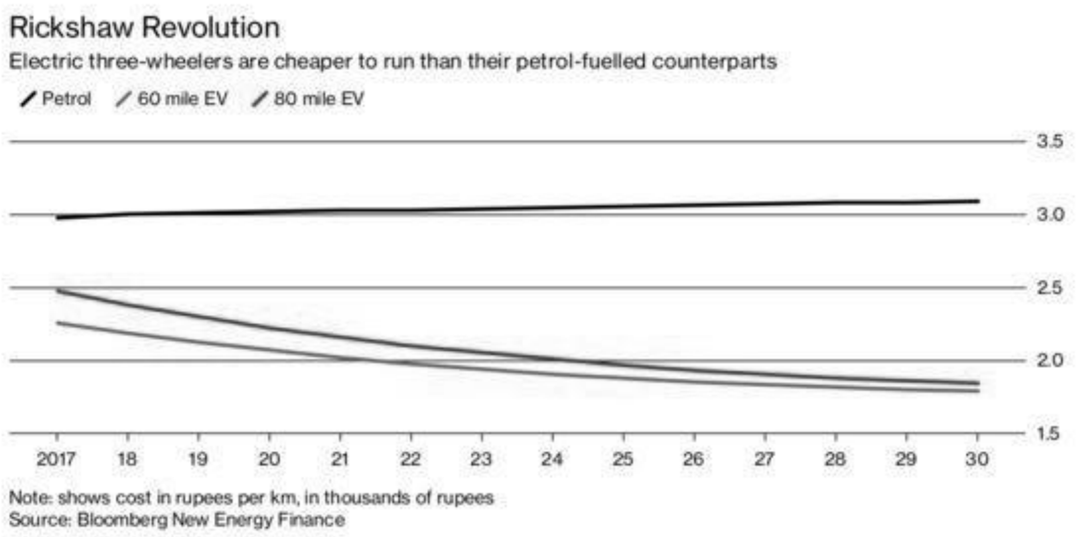

Fig. 5 Three Wheelers and Two Wheelers

Source: https://www.bloombergquint.com/business/india-s-rickshaws-outnumber-china-s-electric-vehicles

The comparative advantage of E-vehicles over ICE ones is the lower cost for distances below 100 km as charging costs for the same are lesser than fuel costs. This makes them a lucrative alternative for rickshaws and motorcyclists in cities and towns. There are an estimated 1.5 million E-Rickshaws [11] in the country and 4,50,000 E-bicycles sold in the last eight years. India is the world's largest market for three-wheelers. E-Rickshaws notably have a higher fleet in India than China and they have managed a large presence without government assistance [11, 12]. The three-wheeler market is worth $1.5 billion and for the aforementioned reasons, is the major focal point for policy making to advance E-Vehicular transport. Cab aggregators, that are dominating the urban transport market, seek to introduce E-Vehicles in their services as well. This further increases the scope for the future market. The current issue regarding E-Rickshaws is the usage of the illegal lead acid batteries which is rampant in the absence of low-cost lithium-ion batteries. The production and supply of such batteries is of paramount importance. Secondly, there is a lack of adequate banking finance for rickshaws in India which significantly hinders growth and prevents the sector from realising potential. An important role can be understood to be played by government subsidies and easy credit access for E-Rickshaws by banks.

2.10 Charging Infrastructure

India had 425 charging points available publicly by the end of 2017. By 2022, government and private efforts are expected to boost that to an estimated 2,800 charging points, according to BNEF [13]. It has been a primary concern for the Indian Government to enable a widespread charging infrastructure for the country; especially since long distance travel; over 100 kilometres is highly inconvenient without the same. Standards as developed by the Department of Science and Technology (DST) must be swiftly and concretely provided for the management systems regarding charging points and parks, especially public services. The various ways in which the charging infrastructure can be developed include the usage of DISCOMS for setting up such charge-points at strategic public locations and allowing private services to function with adherence to guidelines and standards as well. The major focus is recognized to be on public rather than private facilities as private facilities may not be easily availed.

2.11 Expression of Firms' Decision Strategy

There are two categories of players in the upcoming market; large automakers that are investing in Electric Vehicles such as M&M, Suzuki, etc. and fresh enterprises, many of them start-ups, that seek to provide customised technology in the market. Firms providing charging facilities may be independent or subsidiaries or collaborators of manufacturers. We consider all such firms in the following. Profit function of the manufacturer/seller:

There are two conditions that need to be satisfied for the firms to invest in India;

$(i)\ E(\pi_i) > 0$ For investment in the ith year, which is the year in which manufactured vehicles are brought to the firm must expect profit to be positive.

$(ii)\ \frac{dE(\pi_i)}{dt_i} > 0, [i \to 1, \dots 30]$ For long term investment, conventionally for thirty years, expansion prospects depend on profitability. The returns of the company must be expected to grow with time for the initial period in the emerging market. We consider the profit function as follows:

$E(\pi_i) = E(D_i.P_i - cD - F)$, where D_i is demand in the i^{th} year, P_i is the price in the year, c is the cost per unit output and F is the fixed cost of investment.

$c = f(w_K, w_L)$, w_k and w_L are the rental rate of capital and the wage rate of labour respectively. A firm's variable cost is a direct function of these two. In general, it is taken

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that greater labour availability implies lesser wages and vice versa and the same for capital resources.

3. DEMAND CONSIDERATIONS

The demand for Electric Vehicles cannot be taken by policymakers to arise simply when there is a constraint in the pandemic.

3.1 Current Measures: FAME

The Faster Adoption and Manufacturing of (Hybrid) Electric Vehicles Scheme, currently in its second phase, is the Government of India's project that is focused on developing the Electric Vehicle Segment in the economy.

3.1.1 FAME I

This scheme was aimed at generating awareness about Electric Vehicles and increasing the readiness for the market to be set up along with active reduction as well. As per the evaluation carried out by the Government, it was found that the overall outcomes on fuel saving and CO2 reduction were significantly lower than the target reductions. It was observed that industry players with potential in this sector were cautious about proceeding and chose to differentiate EV activity from core capabilities. An important note in this scheme was the lack of planning on Electric Three Wheelers which is the primary means of developing a shift to clean technology, as previously elucidated. While the scheme focused solely on demand incentives via price alterations; subsidies, it failed to tap into consumer trends and sentiment which would be of primary importance in establishing reliance on commodities that are new and potentially risky investments but have major social benefits. The lack of investment in such campaigns to develop incentives lowers the cross elasticity of demand between the ICE and EVs which implies a lower impact of subsidies [15].

3.1.2 FAME II

This scheme has its objective in generating a more realised thrust of the EV market in India via an infrastructural layout and further demand incentives. We find the scheme having the same flaw that the FAME I did; reliance solely on subsidies for the control of emissions which are not conducive enough due to low elasticity. Furthermore, among EVs used for public transport and commercial purposes, there is a uniform subsidy of INR 10,000 provided for all models which again, is understandably an inefficient incentivisation model as various vehicles have different emission rates and differing attributes that may be positive or negative for the rider and the owner and importantly, have varying prices. A Deloitte Survey found consumer concerns over adequate charging infrastructure to concern 25% of consumers, more than other variables [14]. Hence, the scheme's focus on minimising emissions cannot be achieved as the demand framework is not homogenous. Given the current situation, FAME becomes all the more problematic due to the unfeasibility of subsidies. It is important for the government to seek better measures to deal with the lockdown [15].

3.2 Vehicular Demand Model

I consider the case of the average Indian consumer who would purchase a vehicle. This is generalised across social groups and includes final consumers who drive for private use, self-employed taxicab service people and firms that purchase vehicles for direct or indirect business purposes. For each such economic entity making a purchase, there is a binary choice between an ICE vehicle and Electric vehicle. This is a generalised model applied to different consumers and different types of vehicles. The dual commodity market exists for different categories of two-wheelers, three wheelers and four wheelers. For instance, a rural driver offering private transport services has the choice between an ICE and EV three-wheeler and an urban household has the choice between an ICE and EV four-wheeler for private usage. The following models the purchaser's utility and expresses its relationship with different relevant variables. To the single consumer, the market offers two perfect substitutes for unit consumption of a vehicle. The consumer seeks to maximize utility net of expenditure. Hence, the final utility will be the maximum of the ICE and EV vehicles respectively.

$U = Max[U(X_i), U(X_j)]$, where X_i *and* X_j represent numerical units of Electric and Internal Combustion Engine vehicles purchased respectively. It is given that $X_i = X_j$.

In the standard case, we have $X_i = X_j = 1$. The utility functions are represented as:

$$U(X_i) = f\big(M - (P_i + t_i), P_j, (c_i + \theta_i), d_, \sum a_i\,, Nat_{i,}\big)$$

$$U(X_j) = f\Big(M - (P_j + t_j), P_i, (c_i + \theta_i), d_, \sum a_{ICEV}\,, Nat_j\Big)$$

Here, M is the fixed budget allocation of the economic agent for purchasing a vehicle. $M - (P_j + t_j)$ is the surplus on purchasing j with price P_j *and unit tax* t_j.

Here, $\frac{dU(X_i)}{d(M-(P_i+t_i))} > 0$ $which\ implies\ that$ $\frac{dU(X_i)}{dM} > 0$ and $\frac{dU(X_i)}{d(P_i+t_i)} < 0$, d_i is the total distance that the vehicle i can travel in a month. This variable is a function of the vehicle's capacity, the transport infrastructure and the charging/fuel availability. c_i is the quantified value of the fuelling/charging costs incurred per unit d and θ_i is the depreciation cost per unit d. $\frac{dU(X_i)}{dc_i} < 0$ and $\frac{dU(X_i)}{d\theta_i} < 0$, Ai is the i-th attribute among n vehicular attributes that the vehicle has. The presence of each attribute contributes to total utility derived from the vehicle's consumption. The last variable $Nat_{i,}$ is a measure of the behavioural impact of purchasing and using the vehicle i. Ownership of the vehicle gives a signal to members of the society and may also have moral and/or psychological significance. The variable is a quantified value of positive significance of ownership. $\frac{dU(X_{EV})}{dNat_{i,}} > 0$ To generate demand substitution from ICE to EV in a market, the utility from an EV to the average consumer must be greater than the utility from an ICEV. Vehicular attributes are determined independently by private firms and are assumed to be beyond the policymaker's influence. Theta is taken to be a constant which is equal for both since it is determined by private players and entrants in the EV market are assumed to be efficient firms with developed technology. C for an ICE primarily includes the cost of fuelling. For an EV, it comprises charging costs. We assume that d_i is the same for both vehicles. Substituting in the Expected Profit function of firms, we get:

$$E(\pi) = (P_i - c)n.E[U(X_{EV}) - U(X_{ICE})]$$

4. GOVERNMENT STRATEGY

4.1 Pandemic Induced Constraints

Government relief packages during the Covid-19 pandemic have increased the fiscal deficit manifold. Considering the collateral damage to numerous sectors, especially labour-intensive ones and MSMEs, it is unfeasible for there to be large Electric Vehicle subsidies, especially considering the gestation lag in returns. Supply chain disruptions across the globe have caused supply crunches. The transport of lithium and other materials is restricted, causing a supply crunch. Moreover, income constraints because of reduced economic activity and unemployment shall reduce demand for vehicles in general. However, resumption of supply chain links and increase in income can be reasonably expected post the recession.

4.2 Disruption of the Automobile Sector

The ramifications of "creative destruction" of the ICE automobile sector on employment and growth are certainly concerning for the economy. In the short run, a shift in the demand shall lead to production cuts and layoffs in the industry which shall increase unemployment and hamper growth. The recent economic slowdown of the economy which has particularly impacted the automobile sector is partly attributed to government support to EVs and stringency for ICEs. In light of the slowdown caused by the pandemic, the implementation of an EV supporting policy is even riskier for the government. However, in the long run, the negative impact shall not be felt as several of the large automakers in the industry are well aware of the need for an EV shift and have been provided a sufficient gestation lag in the infrastructure set-up of the country, including battery production and charging infrastructure, to commit to Research and Development and shift their production lines to Electric Vehicles, especially since the Government provides a favourable environment in these regards. There is also scope for market share retention with existing brand values. The shift in production line shall still require largely similar functions in assembly, repair, etc. which will employ the same nature of labour with minor adjustments and perhaps slightly lower jobs but the same

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cannot be fathomed as a significant enough cost to not allow the transition. The opposite stance on ICE engines is taken as import duties on oil, higher GST rates for purchase of vehicles and lower benefits reduce market share and make production less profitable. An All India Study conducted by M/s Nielsen (India) Pvt Ltd for Petroleum Planning and Analysis Cell (PPAC) of Petroleum Ministry showed 70% of diesel and 99.6% petrol are consumed in the transport sector alone [16].

4.3 Deficit Concerns

One of the objectives of the EV push in India is to reduce its heavy dependence on oil imports which is largely generated by the automotive sector. This shall definitely be seen as possible when there is a demand shift in favour of EVs. However, as mentioned, the lack of lithium reserves in India as well as the absence of advanced technology of the kind found in the West shall require massive imports for a fully functional industry. The MoU with lithium rich countries like Bolivia and Direct Investment by Multinational Corporations in Joint Ventures shall generate lower import bills. However, in the initial investment period, the market shall not be active and automotive dominance will persist. Shift in consumer demand will also take time. Infrastructure and oil imports at this time will worsen the deficit Fiscal packages during the pandemic alongside poor tax collections have enlarged budget deficits of governments, making persistent, let alone increased, subsidization unfeasible. The best alternative for the governments, therefore, is to promote Foreign Investment in the EV sector as capital inflows shall balance imports, preventing excessive trade deficit enlargement. Investment is needed not just in vehicle manufacturing but also in charging facilities. The expectation of profits for investors must be high enough to induce capital inflows. Hence, expected demand must be high.

4.4 Co-Ordination between Buyers and Sellers Via Social Value Creation

Given the outlay, the following payoff matrix shows the co-ordination game between buyers and sellers for the EV market in India. Investment for sellers extends beyond the simple manufacture of electric vehicles to the development of charging facilities, active attribute development of the products and providing relevant clientele services to the consumers. Expected profits of sellers need to be high enough for them to invest while buyers suffer if they purchase available electric vehicles but cannot avail adequate charging facilities and other relevant infrastructure for their commodity.

Table 1. Payoff Matrix

FIRMS/BUYERS	Purchase	Don’t purchase
Invest	$\pi > 0, U > 0$	$\pi < 0, U = 0$

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Don't Invest	$\pi = 0, U < 0$	$\pi = 0, U = 0$

The firm's expected payoff on investing is $p\pi_{Purchase} + (1-p)\pi_{Don't\ purchase}$

Here, $p = 1\ when\ U_{EV} > U_{ICE}\ and\ p = 0\ when\ U_{EV} < U_{ICE}$.

In the case that $U_{EV} = U_{ICE}, p = 0.5$. We assume this to be a case of normal profit for the firm where $\pi = 0(or\ slightly\ greater)$. Given other factors, scarce charging facilities make the cost of owning EVs that require that infrastructure high. Also, the distance the EV can then travel is lower. This causes utility to be lower than that for ICEs, ceteris paribus. Given $E(U_{EV}) < E(U_{ICE})$, demand is low. Low demand, in turn, is a poor signal to firms that would invest in charging infrastructure as it reduces their expected profitability. We therefore find the situation to be at the undesired game equilibrium. In order to alter incentives, the government must raise E(U) by means of other variables. The most plausible such variable is Nat_i. The social value of an Electric Vehicle is much higher than that of an ICE vehicle because of its environmental benefit and its signal of development. Given that ICE vehicles pollute, people would prefer Electric Vehicles over them if the environmental benefits are propagated by public means [17], $\frac{dU(X_i)}{dNat_{i,}} > 0$

If Nat_i rises for EVs and falls for ICEs, $dU(X_{EV}) > 0\ and\ dU(X_{ICE}) < 0$. If trends show consumer preference for electric vehicles, expected utility and therefore, expected demand shall be high, leading to investment in charging infrastructure. With added infrastructure, the demand shall be even higher as utility will increase further with low costs and higher distance capacity of the vehicles. Hence, the game can be solved for a desired equilibrium to be achieved.

4.5 Policy Recommendations: Altering Nat_i

1. **Awareness through a nationalistic lens**: Information on the benefits of Electric Vehicles to the technological advancement, global standing and general socio-economic welfare of India should be highlighted and made known to the different social segments.

2. **Go-green media campaigns**: The Central and State governments must collaborate on a single campaign or multiple campaigns that have cultural and social connections to consumers in concerned regions with the stated motive of national welfare.

3. **Collaborative schemes with private sector enterprises** for carrying out EV promotional activities for their employees and strategizing incentives for switching using Nudge theory and other behavioural concepts.

4. **Pitches to and talks with Multinational Companies** for infrastructural outlay and component manufacturing investment plans in India. Given successful initiation of the above, the signal for expected demand in the economy for the potential investors to consider capital infusion will be generated. The governments must then ensure proper smooth transitions.

5. A COMPARISON WITH CHINA

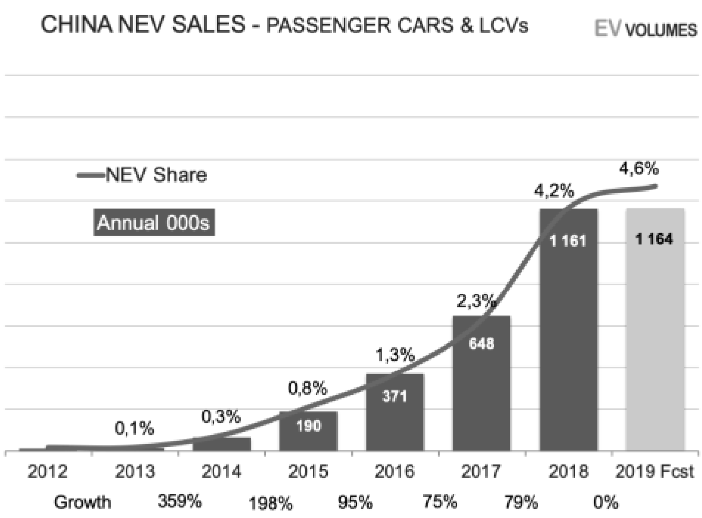

Fig. 6 Electronic Vehicle Market in China

Source: https://www.ev-volumes.com/country/china/

5.1 EV Market in China

Around 45% of electric cars on the road in 2018 were in China – a total of 2.3 million – compared to 39% in 2017. In comparison, Europe accounted for 24% of the global fleet, and the United States 22% [17]. This section analyses how China managed to create a substantial EV market for itself.

5.2 *Direct Role of the Government*

The Case of the Chinese Market for Electric Vehicles involves growth primarily via government regulation in the sector. Having begun the development of its EV market in the 1990s, China now has the largest global share of the same. The enforcement of bans on gasoline powered bikes in cities made EVs the most viable alternative. The ease of producing, selling and buying electric vehicles was actively increased by the Chinese Government when it stopped licensing for electricity powered cycles, recognizing them as "bicycles" and allowing their riders to use bicycle lanes. The Chinese government invested heavily in subsidies to consumers and subsidies for electric vehicle batteries that have helped

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increase demand significantly. Further, the use of electric-bicycles was included as one of the 10 key scientific-development priority projects in the country's ninth Five-Year Plan [18].

An estimated 8.5 billion yuan has been channelled into the green car industry from the capital market so far. The fund would help build up the country's battery output, which will be capable of supplying 150,000 electric vehicles by October 2011. The Chinese Government had planned the spending of more than 100 billion yuan to subsidise the green vehicle industry over 10 years, in 2010 [18].

5.3 Active Market

SAIC, FAW, Dongfeng, Chana, BAIC, GAC, Chery, BYD and Geely are Chinese companies in the domestic EV segment. The existence of these enterprises in a competitive market for a number of years has led to massive resource utilisation and development; unprecedented in other countries due to the lack of such enterprise. The research and development undertaken by these companies helps develop the efficiency of EVs. Alongside these, there are various research institutes in China that are highly focused on technological advancement in Electric Vehicles.

5.4 Resource Acquisitions

China has focused on major acquisitions of lithium resources across the globe; in South America and Australia, having reportedly spent $2.4 billion in South America as of January 2019. Chinese entities are said to control nearly half of global lithium production and 60 percent of electric battery production capacity [19, 20]. The aggressive purchasing strategy by China for lithium reserves has given it a crucial edge in the global EV market.

5.5 Lessons for Government Role

Considering the harmful nature of gasoline-based motorcycles, it is in India's interests to ban them. Although this is currently unfeasible, it can be done post-recession recovery. A highly beneficial strategy, as implemented in China, would be the de-licensing of electric two wheelers the way they have been in India. Secondly, given the absolute state control in China, it is easier for the government to facilitate demand changes. Although India cannot do the same, being a democracy, nationalistic sentiments and active awareness campaigning can be substitutes for changing market preferences. Concerns here arise due to the persistent hazards of Indian traffic and sub-cultures of non-adherence to road regulations. However, this policy is readily adoptable for Electric two wheelers with lower speed capacities as a boost to the industry. A potential advantage India has in this sector is the strength of the three-wheeler market; as seen in China, state incentives that make it easier for businesses to operate using EVs have proved beneficial and here, there is a need for easy acquisition and running of these vehicles. Credit availability by state run banks and reduced regulation in obtaining E-vehicles alongside taxation benefits shall boost the demand for such vehicles. Also, taxation benefits to software-based cab aggregators for electric three wheelers and two wheelers shall introduce lucrative incentives in a competitive sector.

5.6 Resource Availability

The dominance in the supply side has been crucial to China's growth. There is an urgent need for India to create strong links for low cost availability of lithium carbonate, cobalt and other necessary raw materials. In this regard, the acquisitions sought by Khanij Bidesh Ltd. in South America and Australia as well as the MoU between India and Bolivia seek to be highly important for ready availability. It is in India's interests to have further acquisitions in the same regard.

5.7 Market Development: Foreign Collaboration

State investment in R&D has been major contributors to growth in China. The same must be done via focused projects by the Department of Science and Technology and institutions like the Indian Institutes of Technology for providing means of achieving greater efficiency. It is notable here that while there have been foreign collaborations for Chinese firms, FDI in EVs have not been a pusher of growth in the country. However, the noticeable fact in China's self-sustenance here is that the growth objectives have been met over more than two decades since inception and with high quality of technology, both of which are not feasible in India's considerations. In this regard, it is necessary for India to collaborate with MNCs initially, especially firms such as Tesla and Panasonic, with their self-stated goals of electrification in Asia.

6. IMPACT

6.1 Environmental Benefit

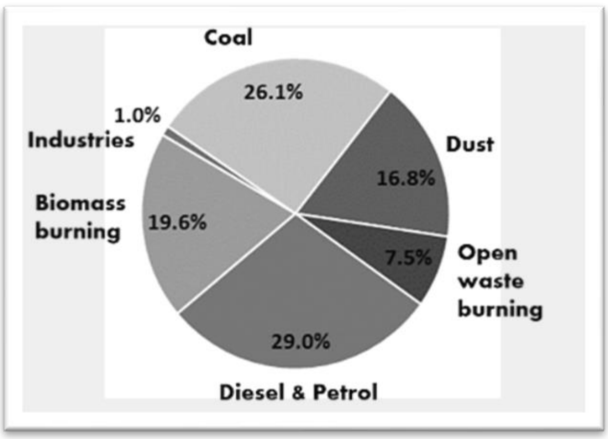

Fig. 7 Environmental Benefit

Source: https://urbanemissions.info/blog-pieces/whats-polluting-delhis-air/

Delhi in India, as per a WHO survey, is the most air-polluted major city in the world. A major contribution to the same is the vehicular emissions in and around Delhi. Vehicular emissions have various environmental costs which include various diseases and health hazards. The global cost of transportation-attributable health impacts in 2010 and 2015 was approximately USD one trillion. Being the second largest population in the world and with often failing control mechanisms, India involves a large portion of this expense. Reducing reliance on carbon emitting fuel and shifting to Electric Vehicles shall majorly benefit the Indian society and economy. The indirect benefit of lower GHG emissions in India via reduced heating and climate change shall protect the interests of agriculture and forestry based endogenous communities and assist bio-diversity preservation.

6.2 Shift from Oil and Employment Generation

European Climate Foundation has estimated that through reducing oil demand by more efficient electric cars, employment will increase by 5,00,000 to 8,50,000 by 2030 [21]. In Europe, oil production and distribution has very low employment intensity of just four jobs per million Euros value added compared to 24 jobs per million Euros in the general economy and we understand a similar difference in the Indian economy [22]. Therefore, any shift in expenditure from buying imported oil to other expenditure choices can be understood to generate excess employment.

6.3 Rural Connectivity

Metro and bus services are unavailable in most areas in the country that lie outside the ambit of large cities. In such towns and cities, the only public transport options available are auto or manual rickshaws. Hence, early conversion of these rickshaws to Electric Vehicles using Lithium-Ion batteries shall provide clean transport to a significant number of individuals. Three-wheelers and two-wheelers are the primary mode of transport in most villages for reaching bus-stops or highways. Quick conversion to electric vehicles here will ensure clean transport in villages, especially with battery charging and swapping outlets in larger villages, which are employment generating. This shall also see penetration in freight movement and agricultural connectivity in rural areas that are managed by rickshaws, autos and tempos which are suited for replacement with Electric Vehicles. All of the above results aggregate the positive impact of an EV shift in India.

7. CONCLUSION

In the absence of industrious policies for the future growth of Electric Vehicles, the future introduction of Electric Vehicles shall be problematic for the government with regard to its fiscal problems which have been exacerbated by the 2020 pandemic. As the developed world is focused on early adoption of Electric Vehicles and direct competitors like China have already been successful in the same, it is imperative for India to develop self-sustenance in EV manufacturing and leverage in global markets as it would otherwise make the economy more reliant on imports and vulnerable to market shocks and unfavourable policies of other governments. While ties with South American and other governments have been established and potential plans have been made, foreign direct investment and active private sector participation via foreign direct investment are primarily needed for economic boosts to the sector. India has a key opportunity in harnessing strong nationalistic sentiments for the creation of effective demand to do away with coordination failure in the EV market with minimized burden on the financial resources of the country. Moreover, the successful implementation of such campaigns would augment the generation of desired market equilibria without direct price interference by the government.

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