

## PRIMARY ANALYSIS OF ELECTRIC TRACTOR MARKET IN INDIA

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#### **Abstract:**

The most promising and enthralling technology of age is the Electric Vehicle (EV) technology. It has been neutralizing the growing menace of carbon emission and reducing the dependence on fossil fuel and excessive energy consumption. The EV technology has been making a mark commercially in passenger segment since the year 2000 and with the impressive feat achieved in the category the technology has marched towards the heavy motor electric vehicles (HMV) the non-transport goods carriage and agriculture automobiles.

India being largely an agriculture supported economy, the advent of electric vehicle technology in the LMV sector particularly in the tractor market necessitates appreciating and investigating the aspects that guides the consumer's in this case the farmers willingness to adopt the EVs . The foremost aim of this research is to investigate the effects of price, government subsidies, emissions, fuel efficacy, performance and maintenance on consumer's intention to adopt EVs. The research is empirically conducted using structured questionnaire, the survey data was collected from 400 respondents from farmlands in north Indian regions to assess market acceptance for an electric farm tractor and to discover the extent of influence exerted by various variables on buying decisions. The deductions from the study indicates that perceived superior fuel efficiency in electric vehicle is positively and significantly related to attitude and intention to adopt EV and negatively and significantly related to vehicular emission and its subsequent impact on environment. Whereas, government financial subsidies and perceived low maintenance is positively and significantly related to adoption intentions of EVs. However, the results also indicate that the lack of information and knowledge about post purchase maintenance outlay has a negative impact on intention to adopt EVs. According to the findings of the Probit regression analysis, age has a negative and significant impact on consumers intention to acquire an electric tractor. Based on the results, policy implications for increasing the adoption of EVs and suggestions for future research are discussed

**Keywords-** Electric tractor adoption, diffusion of tractor; alternate fuels; hybrid electric tractor, adoption intention, financial incentive

#### **Introduction:**

Profitability with sustainable solution has been the recent guiding principle for the automotive industry that has been struggling with dip in sales due to the unprecedented rising fuel cost, (Mr Sharif Qamar et al Jul 2020) and environmental catastrophe such as such as the

fossil fuels depletion, greenhouse emission and climatic disparities [Susan A. Shaheen et al]. Such events have fuelled the search for unconventional fuel technology.

The electric vehicle has alternated fossil fuel and catered the possibility to lessen the greenhouse gas emissions, primarily due to the advent of batteries (CASTRO & FERREIRA, 2010). The electric vehicles have been in the urban market in passenger segment since the year 2000, where the advantage of the technology has been acknowledged and accepted as compared to the parallel petrol/diesel engine (SCHWARTZ et al., 2009).

The remission for environment and scarcity of fossil fuel does not stop at the urban mobility, in fact the vastness of the environmental issue at hand has extended the premise of alternative fuel technology to the agriculture sector also [Malik et al (2020)]. The rural requirement for activities that require traction force, are still largely covered by tractors that run by ever polluting internal combustion engines. The rural requirement has attracted the electric vehicle manufacturers and researchers alike. Unlike the heavily researched urban vehicle market the agriculture industry and implication of electric vehicle on it is yet underexplored.

As the rural ingesting of the electric vehicle technology is in nascent stage it open avenues of research to understand the trajectory for the technology in rural market. The research aims at assessing the acceptability of electric tractors in the untapped agriculture farm tractor market. The probe here is to ascertaining the acceptability of new technology in wake of deep rooted traditional methods of farming and be factors effecting willing to purchase an electric.

The research furthers with its second objective so as to determine the factors that would have the utmost impact on the acceptance of an electric tractor.

### **Literature Review:**

Comprehensive studies have been conducted globally to comprehend process of EV adoption by consumers in passenger segment EV vehicles [Peters and Dütschke (2014), Rasouli and Timmermans (2016), Valeri and Danielis (2015), Barth, Jugert, and Fritsche (2016), Beck, Rose, and Greaves (2016)],

Various factors deliberated are the financial aspects, charging infrastructure, charging time, availability of battery and battery cost. Other important factors like financial and non financial incentives offered by the various governments have also been scrutinized.[Bahamonde-Birke and Hanappi (2016), Helveston et al. (2015), Mabit, Cherchi, Jensen, and Jordal-Jørgensen (2015)]

The research was further extended to the study of charging station, infrastructure and policy by Chorus, Koetse, and Hoen (2013). Aasness and Odeck (2015). Beresteanu and Li (2011) concluded the positive impact of income tax inducements increases EV market share.

In passenger segment another very important factor is environmental concern. Environmental concern has been one of the defining parameters as the willingness of individual to do

something to resolve the issue leads to their willingness to support the electric vehicles Kahn (2007) and Pierre, Jemelin, and Louvet (2011).

These researches though very critical have limited application to the novel unexplored rural market, a market for electric tractors here the agricultural activities entails traction force [MOUSAZADEH et al., 2010]. SERRANO (2007), concluded that the factor driving the purchase of a tractor is to be able to fulfil the requirement of heavy power for the implements like plow disks and subsoilers. This need is largely addressed by the traditional internal combustion engine run tractors. According to [BARDI et al. (2013)], the agrarians started using renewable energies; though late, but an essential and expected progression. The role these ICE tractors play in air pollution has been highlighted in the study conducted by MOUSAZADEH et al. (2010), establishing the relevance of incumbency of electric vehicle technology in the agrarian works.

Research conducted by (CARVALHO, 2008] highlighted the fiscal and conservational concerns, as the rousing force behind the automotive industry galloping the production of electric vehicles with the intention of dipping the usage of depleting fossil fuels.

The perimeter of this research is to establish the marketable possibility of electric tractors in wake of the role they play in being a sustainable alternative to gasoline guzzling internal combustion engine options available mainstream to the farmers in an agriculturally dominated economy like India.

Preliminary investigation presented the inadequate body of work done to study the growth and sustainability of an electric farm tractor. This led to the premise that the connection between electric vehicle and ICT vehicles are comparable in standard. The research needs to be extended to the agriculture equipment with special reference to the electric farm tractor with a believer to explore the other factors that could diverge from the LMV market to the agricultural farm tractor market (“Hybrid electric vehicles in the United States”, 2012).

### **Objectives:**

If electric farm tractor were to be introduced into this untapped agricultural farm tractor market, would farmers accept the technology and be willing to purchase a tractor of this kind? The primary purpose of this study is

1. To investigate whether the agricultural communities are willing to pay high differential price for the benefits of a hybrid electric farm tractor.
2. A secondary goal of the research is to establish which major consumer characteristics would have the most effect on the acceptability of a hybrid electric farm tractor.

### **Significance of the Problem:**

With the quest for alternate powered and environmentally conducive technologies, many academics regard electric technology as the most promising technology for the near future. Electric technology improves fuel economy and reduces pollution. Some customers,

particularly in the passenger car sector, favour the technology since it produces less emissions and produces less pollution than other technologies. A market analysis to assess the acceptability of electric technology for farm tractors has not been conducted. This exploratory investigation will serve as an indicator of the possibility of a hybrid electric farm tractor's success if one is created.

## **METHODOLOGY**

Descriptive research design has been used in this study. The objective of a descriptive study is to answer the who, what, where and how of the subject under investigation. Target population are the agriculturists in India and sample frame being the farmers from the northern region of India namely state of Haryana, Punjab and Uttar Pradesh. Probability and Stratified Random sampling was used in the study. Proposed stratification parameter used were income and education. Subsequent sampling was Simple random sampling

A survey design often results from a deductive approach and is capable of collecting large volume of data apt for statistical analysis. Hence survey design was used in this research. Questionnaire was developed with reference to the published work of Dr. Xu et al (2012). The survey was designed to analyse tractor purchase decisions based on five factors: retail price, emissions, Fuel efficacy, performance, and the bearing of upkeep and reparation.

The survey was designed with 22 questions, with initial 8 questions being demographic questions followed by question number 9-22 explicitly identifying factors effecting purchase decision for electric farm tractors.

To ascertain the sample size various studies suggest a suitable sample size to be 100 or 200 (Boomsma, 1985), 5 or 10 observations per estimated parameter (Bentler & Chou, 1987; Bollen, 1989) and 10 cases per variable (Nunnally, 1967) as different thumb rules. This research has 378 valid filled responses.

Four hundred surveys were administered personally. Out of which twenty two surveys were missing information hence were not included in the analysis. The data was mined to ascertain the frequency, percentage, cumulative percentage, standard deviation, and statistical mean of responses were in from the data analysis.

The data was further mined by performing a linear regression and a probit regression analysis. The linear regression and probit analysis specify the existence or absence of any correlation that exists between the dependent and independent variable.

The dependent variable in the stated case is the willingness to purchase an electric tractor. The following independent variables age, years in trade, land size, number of tractors, maintenance cost, environmental concern (reduced emission) , knowledge about the technology, maintenance cost, fuel efficacy and the importance of tractor purchase price were selected to perform the data analysis.

**Hypothesis:**

H1: The increasing age of the farmer has a diminishing impact on the acceptability of electric tractor

H2: The readiness to acquire an electric tractor is diminished with the increase in spending on maintenance.

H3: If Government Subsidizes Price there is a positively impacts on farmers willingness to purchase an electric tractor.

**Data Analysis:**

**Broad Tendencies Purchase decision ranking:** To evaluate the comparative eminence the various purchase factors were pitted against each other in the survey and the respondents were surveyed to rank the five purchase decision factors from five to one, where 5 was the most important and 1 the least.

Figure 1 below clearly represents that the bulk of respondents agreed, that when purchasing a farm tractor, reliability is the most significant factor and effluence generated from the use of the t is the least vital factor. The other factors that closely impacted the decision were purchase price, fuel efficiency, and self-repair. Technically the data tabulation indicates that the majority of respondents ranked the five factors, from most important to least, as performance, fuel efficiency, price, maintenance and pollution.

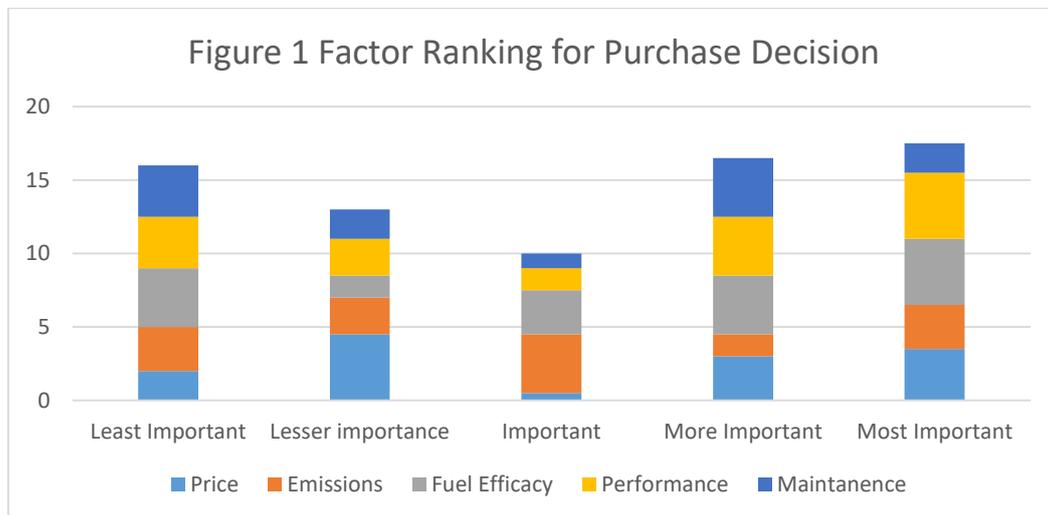


Figure 1 depicts the price of acquiring a farm tractor as the most important factor and impact on environment the least thought about factor. The other factors such as government subsidies, fuel efficiency, and maintenance were equitably close. The factors were ranked as

follows from most considered to least considered price, government subsidies, fuel efficiency, maintenance and impact on environment.

Considering the economic viability of the agriculture sector the deductions that price is the most important factor while purchasing electric tractor makes perfect sense for the Indian market. The other factors divulges that government subsidies is seen as the next most important factor. The nature of the usage of the farm machinery makes maintenance the next most considered factor.

### Linear and Probit Regression

The data was tabulated to epitomize a confidence level of 90% grounded on the point that the code was developed to portray the confidence level at 90 percent. A correlation result is 90 percent valid at 0.1 statistical significance.

The prime dependent variable for this study is consumer's readiness to buy an electric tractor. The research considers independent variables as age, years of experience, acreage, number of employees, maintenance cost farm land location, knowledge, the importance of tractor purchase price and subsidies. Table 1 spells out the code given to the independent variables and explanation for the same.

**Table 1: VARIABLE CODES AND MEANINGS**

Variable Code	Variable Code Meaning
age1	Age
years1	Years of farming or working in agriculture
acres1	Amount of acreage
NoT1	Number of Tractors
maintc1	Annual maintenance cost
Env 1	Environmental Concern
Electric 1	Level of knowledge about electric technology
price1	The importance of tractor purchase price and Subsidies

A significant correlation is observed between the independent variables and the dependent variables in some cases. A significant relationship exists between the government subsidies and price of an electric tractor, Table 2 also indicates that an association occurs between tractor upkeep fee and the government subsidizing the price.

**Table 2: PROBIT ANALYSIS: GOVERNMENT SUBSIDIZED PRICE**

sub2	Coef.	Std. Err.	z	P> z	[95% Coef. Interval]
age1	0.0558031	0.4160058	0.13 0.893 -	0.7595534	0.8711595
years1 -	0.5718077	0.4817966 -	1.19 0.235	1.516112,	0.3724963
acres1 -	0.1747318	0.3444267	0.51 0.612	0.8497957,	0.5003321
hire1	0.1579973	0.3412668	0.46 0.643	0.5108733,	0.8268679
maintc1	0.6067856	0.3472196	1.75 0.081	0.0737523,	1.287323
county2 -	0.0900211	0.3808047	0.24 0.813	0.8363845,	0.6563424
hybridk1	0.2919438	0.3056335	0.96 0.339 -	0.3070869,	0.8909745
price1 -	0.1917141	0.3561073 -	0.54 0.59	0.8896715,	0.5062434

Multivariate Probit regression analysis was used for analysis of likely Electric tractor purchase. Independent variables age (year1) and maintenance were marked as significant as their test value stands below .1. The maintenance also has a positive coefficient indicating a positive impact on purchase of electric tractors if maintenance is high of the available ICE tractors. With a negative correlation with year 1 indicate that with experience of more than 50 years has a negative impact on purchase decision for electric tractors.

**Table 3: REGRESSION ANALYSIS: LIKELY Electric Tractor PURCHASE**

avail1	Coef.	Std. Err.	t P> t	[95% Coef. Interval]
age1	0.1689592	0.1360915 1.24	0.218 -	0.1014103, 0.4393287
years1 -	0.3807917	0.1733872 -2.2	0.031 -	0.7252557, - 0.0363277
acres1 -	0.0411765	0.1123798 -0.37	0.715 -	0.2644385, 0.1820855
hire1	0.1151169	0.1095418 1.05	0.296 -	0.102507, 0.3327408
maintc1	0.1927602	0.109072 1.77	0.081 -	0.0239303, 0.4094507
county2	0.058318	0.1280433 0.46	0.65 -	0.1960624, 0.3126984
hybridk1	0.144066	0.1001227 1.44	0.154 -	0.0548452, 0.3429771
price1 -	0.1620164	0.1141566 -1.42	0.159 -	0.3888083, 0.0647755

Table 3 provides the results from the multivariate probit regression model analysis for a “likely HET purchase.” The results indicated a correlation of two variables including (years1) and (maintc1) maintenance, with the dependent variable of willingness to buy a hybrid tractor when one becomes available. The independent variables years1 and maintenance were identified as significant because their test data was below the .1 value. In the case of the variable maintc1 the coefficient is positive which indicates a correlation for the HET purchase decision when maintenance costs are greater.

In the item of year1 the coefficient is negative with a correlation for over 50 years’ experience having a negative effect on the purchase decision

Linear regression and the probit regression analysis brought forward the following three findings. The willingness to buy an electric tractor increases by 0.1928 for farmers who spend more in tractor maintenance annually with a 90% level of confidence. The willingness to buy an electric tractor is decreased by 0.3808 for farmers who have spent more than 50 years farming or working in the agricultural industry with a 90% level of confidence.

### **Hypothesis results**

The Probit regression analysis puts forward the following main findings:

H1: The inclination to purchase an electric tractor is diminished by 0.3808 for farmers with more than 50 years farming experience with a 90% level of confidence.

H2: The readiness to acquire an electric tractor is diminished by 0.1928 when a farmer spends more on maintenance with a 90% level of confidence.

H3: The regression for “Government Subsidized Price” and “probable electric tractor purchase show a correlation between upkeep cost and willingness to purchase an electric tractor.

## **IV. SUMMARY AND CONCLUSIONS**

There has been a strong movement for renewable energies and renewable energy technologies. Electric powered innovation is applied in a wide variety of industries such as locomotives, huge construction equipment, automobiles, and industrial equipment.

Loaded with benefits like fuel efficiency and reduced emissions, lesser maintenance and lower operating cost electric technology is the need of the hour. The agriculture machinery market in India has yet been unexplored with reference to market potential and acceptance of the electric technology by the agricultural community.

The perceived value addition in the farm by the electric technology is still irresolute hence this introductory market study was undertaken to define the probable allure of an electric tractor and to assess the elements that would expressively stimulate the purchase decision for an electric tractor. As the survey was conducted in the utmost productive agricultural states in India making the data representative of the majority agriculturists in the country.

A descent representation of the population was done as the sample size for the study was of 400 respondents. Five factors including: retail price, emissions, Fuel efficacy, performance, and the bearing of upkeep and reparation were assessed for their comparative prominence in decision making while purchasing an electric tractor.

Contrary to the belief that that the major benefit of the electric technology reduced air pollution is not the primary reason for purchase decisions. The majority of respondents agreed that price (80%) and government subsidies (55%) are extremely important factors when purchasing a farm tractor. Nearly 52% respondents specified fuel efficacy and maintenance to be exceptionally significant.

The emissions generated by the farm machinery has not emerged as a decisive factor in the purchase decision for electric tractors. The agricultural community perceives the new electric technology as high maintenance and acts as a deterrent to positive decision making whereas the actually with lesser moving parts the maintenance cost has been lowered than the traditional internal combustion engines. Another areas that came out in the survey was that 90% of respondents acknowledged that they are unaware about the new technologies and its technicalities, result in a negative perception and negative decision making.

### **Recommendation for Future Research**

1. Future studies might potentially cover a bigger, more diversified population dispersion. A bigger sample size might include people from more farms in other regions providing a more comprehensive picture of the desire to acquire an electric tractor.
2. If a similar study is conducted, it would be prudent to construct a research team comprising of all the stakeholders like the industry professionals and experts, as well as business marketing professionals and experts. To properly conduct a research of this type, these two groups will need to work together. Industry specialists are required to deal with the technical aspects of the study, while business marketing professionals are required to make sense of the market analysis aspects of the study. Both parties' involvement and knowledge in their respective areas are required for a research like this one to be productive.
3. During the evaluation process few questions like likelihood of purchase, training requirement etc were omitted in this study which can be included in the future researches for better correlations between the independent variables and the dependent variable
4. Different stratifications can be created for more meaningful results

This study has produced conclusions contributing to a greater understanding of the purchase behavior of an electric tractor, although more work might still be undertaken.

Limitations: The study was carried out as a qualitative research with a convenience sample. The working ground for the study was limited to the agricultural villages of Haryana, Punjab

and Uttar Pradesh in India. The respondents for the survey included varied mix of large scale farmers, medium sized farmers, small farmers.

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**Author Contribution:** Smriti Khanna and Dr. Archana Mahamuni designed the study and the computational framework. Smriti Khanna carried out the implementation. Dr. Archana Mahamuni appraised the work. Smriti Khanna wrote the manuscript with input from Dr. Archana Mahamuni. Smriti Khanna under the guidance of Dr. Archana Mahamuni conceived and conducted the study.

**Conflict of Interest:** The authors whose names are listed immediately below certify that they have NO affiliations with or involvement in any organization or entity with any financial interest (such as honoraria; educational grants; participation in speakers' bureaus; membership, employment, consultancies, stock ownership, or other equity interest; and expert testimony or patent-licensing arrangements), or non-financial interest (such as personal or professional relationships, affiliations, knowledge or beliefs) in the subject matter or materials discussed in this manuscript.

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