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Impact of EVs on global warming

Deweender Sharvin Sethu
sethud@my.erau.edu

Ho Kai Sheng

Khalish Marican

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Ho Kai Sheng (2614680)

Deweender Sharvin Sethu (2583243)

Khalish Marican (2605784)

Embry-Riddle Aeronautical University

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Dr. Somi Shin

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Abstract

This research aims to define the relationship between electric vehicles (EVs) and the total CO2 emissions of the world. The research question is “does the transition to EVs actually make an impact on the total CO2 emissions”. The dependent variable for this research is the total carbon emissions of 195 countries from 1990 to 2019. This secondary data is obtained from the World Bank. The key independent variable used is the total number of Tesla EVs sold in each country from 1990 to 2019. We use Tesla as the company has an exceptionally high market share in the EV market. Another independent variable used is the energy consumption for each country from 1990 to 2019. We propose to collect the independent variables through an independent data collection company called “bright data”. The results from the preliminary regression analysis show that both the sales number of EVs and the energy consumption are significant. Every EV sold reduces the total CO2 emissions by 26,100 metric tonnes. Every 1 exajoule of energy consumed, increases the CO2 emissions by 30.958 billion metric tonnes. This huge difference in impact suggests that focusing on clean energy would be a better strategy than adopting EVs.

Introduction

Motor vehicles have been widely adopted by the public since their invention in 1892. These motor vehicles were designed to run on liquid fuels such as petrol and diesel. However, the use of such liquid fuels has caused the acceleration of global warming due to Carbon Dioxide emissions. Moreover, the production of petrol and diesel from oil refineries contributes to the acceleration of global warming as the second highest producer of greenhouse gases in the world (United States Environmental Protection Agency, 2013). The development of electric vehicles (EVs) is a strategy the world has deemed to be effective in reducing greenhouse gas emissions as EVs produce zero tailpipe CO2 on the road (Emissions from electric vehicles, n.d.).

Having said that, are EVs an effective strategy when it comes to mitigating global warming? Figuring out the effectiveness of electric vehicles in reducing CO2 emissions, is the aim of our research. This will prevent us from wasting efforts on strategies that will not make a difference. Our research provides carbon emission and EV sales data from 195 countries, more than any past research on this topic. We propose to collect worldwide data on energy consumption as well. This will be done through a data collection company, and we aim to use it to find the difference in impact between EV sales and energy consumption. Using the regression analysis method on the data at hand, we were able to deduce that EV sales have a significant but much less impact than energy consumption.

Literature Review

According to past research, EVs are helping to reduce carbon emissions but the decarbonization of electricity generation is crucial in making an actual difference in overall CO2 emissions (Harrisson, 2021). The life cycle global warming potential of EVs powered by European electricity was found to be 10% to 24% lower compared to that of internal combustion engine vehicles (ICEVs) (Hawkins et al., 2012). Countries such as Sweden, Norway, and France produce renewable electricity while countries such as China depend on the burning of fossil fuels to generate electricity, which greatly plays a part in global warming (Shafique & Luo, 2022). The type of EVs and the type of electricity used to power these vehicles play an important part when it comes to the effectiveness of EVs for the environment (Requia et al., 2018). In that sense, EVs powered by coal electricity are no better than ICEVs when looking at the full life cycle (Hawkins et al., 2012). Separate research also shows that the manufacturing phase generates large amounts of greenhouse gases. Although the use phase of EVs generates 50% less carbon compared to ICEVs, the manufacturing phase nearly doubles the carbon emission of manufacturing ICEVs (Tagliaferri et al., 2016). Studies show that battery production and material preparation for EVs consumes large

amounts of energy, leading to higher carbon emissions in production phases compared to ICEVs (Xia et al., 2022).

Key Ideas

Most research has shown that although EVs have no carbon emissions on the road, the manufacturing process of EVs produces more carbon compared to ICEVs. This is because the lithium batteries used in EVs require raw metals that are mined and refined, producing large amounts of carbon during the process. Research has also shown that the type of electricity used to recharge the battery has an impact on the carbon footprint of an EV. While clean energy reduces emission levels, fossil fuels, natural gas, and coal-fired electricity are not sustainable and produce much carbon. Therefore, while EVs theoretically reduce carbon emissions on the road, many other factors affect the amount of carbon emitted, limiting the benefits of EVs if clean energy requirements are not met.

Recurring Ideas

All the sources are used to support the fact that EVs generate less carbon than ICEVs. The consensus is that the large amount of carbon emitted by EVs comes from the manufacturing phase. However, none of these sources has a conclusion as to whether the EVs can outweigh the increase in CO2 emissions from increased energy consumption.

Contribution

We have contributed to the study regarding the effectiveness of EVs against global warming by including the entire world as our population and sample. This allows us to achieve a low or zero variance which will depict an accurate representation of the population. Another contribution that we will make is to understand the correlation between EV adoption rates and the total CO2 emission of the entire world. Past studies have shown that there is no definitive conclusion made on a worldwide scale.

Research Question

We wonder if there is a difference in the contribution to reducing carbon emissions when consumers convert to EVs as fossil fuels are burnt to generate electricity to power these EVs.

Theoretical Framework

The dependent variable for this research would be the amount of CO2 emission produced by a country. The amount of CO2 emission produced by a country, before and after the country adopted EVs, will be the indicator of the effectiveness of EVs in mitigating global warming. The key independent variable will be the percentage of EVs over the total number of 4-wheel vehicles in the country. The control variables would be the number of industrial factories, power plants, oil refineries, and renewable energy sources. These control variables play a part in the total CO2 emission produced by a country.

Hypotheses

The null hypothesis is that electric vehicles make no change in the total CO2 emissions of the world. The alternate hypothesis would be that electric vehicles do make a change in the amount of total CO2 emissions in the world.

Study design

This research questions the effectiveness of the contribution when it comes to reducing carbon emissions when consumers convert to electric vehicles (EVs), as fossil fuels are burnt to generate electricity to power these EVs. The null hypothesis is that there is no difference in CO2 emissions of countries even if they adopt EVs and the alternate hypothesis is that EVs make a difference in the CO2 emissions of countries.

Population and sample

This study is on the carbon emissions of conventional vehicles and EVs. Carbon emissions impact the entire world in the form of global warming, therefore, our population

and sample used for this study include the entire world. We collected secondary data from various sources that provide information on CO2 emissions for 195 countries. This aids in making the results more accurate as most past research only contains developed countries. Underdeveloped countries are often overlooked but they still add to global CO2 emissions.

Variables and measures

The variables used in this study include carbon emissions and electric vehicle adoption rate. The total carbon emission is observed for 195 countries throughout a period of 30 years, from 1990 to 2019. The adoption rate of electric vehicles, measured by the number of electric vehicles sold in each of the 195 countries, is our key independent variable. Another control variable used is the energy consumption of each country, measured in ExaJoules. Our study aims to find the amount of carbon emission reduction that can be achieved by transitioning to electric vehicles. We also want to find out the impact that electric vehicles have on the amount of energy consumption. Energy consumption is another factor that plays a big part in global warming, as the most used method of energy production is fossil fuels. The use of fossil fuels adds to the total carbon emission of a country. By determining the relationship between electric vehicles and energy consumption, we will be able to find out if electric vehicles are doing more harm than good.

Data collection methods

The data that is collected for this research are, the total emission of Carbon Dioxide per country over 30 years, the electricity usage for transport on a global scale and, the number of Tesla cars sold globally over the course of 6 years as Tesla holds the largest market share of about 65% in the global EV market over the course of 6 years (Dean, 2022).

Total CO2 Emissions per Country

Figure 1

Observations of annual CO2 emissions per Country over the course of 30 years.

	A	B	C	D
1	Entity	Code	Year	Annual CO2 emission
43	Afghanista	AFG	1990	2024326.1
44	Afghanista	AFG	1991	1914301
45	Afghanista	AFG	1992	1482054
46	Afghanista	AFG	1993	1486943
47	Afghanista	AFG	1994	1453829
48	Afghanista	AFG	1995	1417327
49	Afghanista	AFG	1996	1370104
50	Afghanista	AFG	1997	1304152
51	Afghanista	AFG	1998	1278504
52	Afghanista	AFG	1999	1091640
53	Afghanista	AFG	2000	1047127.94
54	Afghanista	AFG	2001	1069098
55	Afghanista	AFG	2002	1340995
56	Afghanista	AFG	2003	1559602
57	Afghanista	AFG	2004	1237247
58	Afghanista	AFG	2005	1889507
59	Afghanista	AFG	2006	2159318
60	Afghanista	AFG	2007	2799909
61	Afghanista	AFG	2008	4254477
62	Afghanista	AFG	2009	6391888
63	Afghanista	AFG	2010	8364803.5
64	Afghanista	AFG	2011	11838316
65	Afghanista	AFG	2012	10035314
66	Afghanista	AFG	2013	9250510

1	Entity	Code	Year	Annual CO2 emission
31325	Zimbabwe	ZWE	1996	14908902
31326	Zimbabwe	ZWE	1997	13911984
31327	Zimbabwe	ZWE	1998	14131139
31328	Zimbabwe	ZWE	1999	15727769
31329	Zimbabwe	ZWE	2000	13818202
31330	Zimbabwe	ZWE	2001	12508722
31331	Zimbabwe	ZWE	2002	11895839
31332	Zimbabwe	ZWE	2003	10609583
31333	Zimbabwe	ZWE	2004	9428642
31334	Zimbabwe	ZWE	2005	10698489
31335	Zimbabwe	ZWE	2006	10365461
31336	Zimbabwe	ZWE	2007	9835161
31337	Zimbabwe	ZWE	2008	7720094
31338	Zimbabwe	ZWE	2009	8249769
31339	Zimbabwe	ZWE	2010	8754012
31340	Zimbabwe	ZWE	2011	10363199
31341	Zimbabwe	ZWE	2012	11253769
31342	Zimbabwe	ZWE	2013	11671374
31343	Zimbabwe	ZWE	2014	11946148
31344	Zimbabwe	ZWE	2015	12254954
31345	Zimbabwe	ZWE	2016	10533453
31346	Zimbabwe	ZWE	2017	9596071
31347	Zimbabwe	ZWE	2018	11795478
31348	Zimbabwe	ZWE	2019	11114607

Figure 2

Descriptive Statistics for Annual CO2 emissions globally

Annual CO2 emissions	
Mean	379988081.1
Standard Deviation	1799875809
Minimum	0
Maximum	37123850000

Figure 1 shows a data set from Our World in Data. It is to be noted that Figure 1 only shows the first and last countries in alphabetical order. The data is a panel series data as it provides information on individual CO2 emissions in tonnes of 195 countries globally over the course of 30 years, from 1990 to 2019. This will be the dependent variable in our study.

The descriptive statistics for the data are shown in Figure 2. In the preliminary test, we added up the amount of CO2 emission by each country to obtain the global CO2 emission.

Electricity Usage for Transport

Figure 3

Observations for Global Annual Electricity Usage of Transport in ExaJoules.

Year	Energy consumption (EJ)
1990	0.9
1991	0.9
1992	0.8
1993	0.8
1994	0.8
1995	0.8
1996	0.8
1997	0.8
1998	0.8
1999	0.8
2000	0.8
2001	0.8
2002	0.8
2003	0.9
2004	0.9
2005	0.9
2006	1
2007	1
2008	1
2009	1
2010	1.1
2011	1.1
2012	1.1
2013	1.2
2014	1.2
2015	1.2
2016	1.3
2017	1.3
2018	1.4
2019	1.5

Figure 4

Descriptive statistics of the Global Electricity Usage of Transport.

Energy consumption (EJ)	
Mean	0.99
Standard Deviation	0.205694786
Minimum	0.8
Maximum	1.5

This data set is collected from IEA, and it is a time series data as the data provides information on electricity usage for transport over the course of 30 years, from 1990 to 2019.

The unit of measurement is in exajoules (EJ). As shown in Figure 4, the data has a mean value of 0.99 with a standard deviation of 0.206. It has a min and max value of 0.8 and 1.5 respectively.

Number of Tesla Cars Sold Globally

Figure 5

Descriptive statistics for the number of Tesla Cars Sold Globally

	Year	Units sold by Tesla
2	2014	35000
3	2015	51095
4	2016	83922
5	2017	100757
6	2018	254530
7	2019	365232
8	2020	509737
9		
10		
11		
12		
13		
14		
15		
16		

Year		*Units sold by Tesla*	
Mean	2017	Mean	200039
Standard Err	0.81649658	Standard Err	68822.2534
Median	2017	Median	100757
Mode	#N/A	Mode	#N/A
Standard Dev	2.1602469	Standard Dev	182086.567
Sample Varia	4.66666667	Sample Varia	3.3156E+10
Kurtosis	-1.2	Kurtosis	-0.5325867
Skewness	0	Skewness	0.92874394
Range	6	Range	474737
Minimum	2014	Minimum	35000
Maximum	2020	Maximum	509737
Sum	14119	Sum	1400273
Count	7	Count	7

This data set is collected from Backlinko and it is a time series data that provides the units of Tesla electric vehicles sold, over the course of 6 years, from 2014 to 2020. The unit of measurement is the number of cars. As shown in Figure 5, the data has a mean value of 200039 with a standard deviation of 68822.25. It has a min and max value of 35000 and 509737 respectively.

Proposed data collection

Currently, we do not have the dataset for EV sales and the electricity usage of transport in each country from 1990-2019, however, we have gathered the preliminary data with regards to the significance of global EV sales and global electricity usage in relation to the total CO2 that is produced globally. Our aim is to subsequently gather the data state of each individual country for 195 countries and make a comparison. The proposed method for collecting this data is to gather the finance and collect data via companies that specialize in global data collection such as Bright Data. The data that will be collected is the total EV sales and the total electricity usage for each country within the years 1990-2019.

Data Analysis Methods

The Regression Analysis method is used to test the relationship between the dependent variable, total CO2 emission of each country, and independent variables, the number of EV units sold by Tesla in each country, and electricity consumption for transportation in each country. We use the Regression Analysis method because we want to find out how much each independent variable impacts the total carbon emission of each country.

In the preliminary regression test, all variables are substituted with global data as we do not have enough reliable data on each country to successfully conduct a regression test. This means that in the preliminary regression test, the dependent variable is the global CO2 emission while the independent variables are the number of EV units sold by Tesla globally and the global electricity consumption for transportation.

Justifications

The number of EV units sold by Tesla is used as an independent variable as Tesla is the largest player in the EV market, outselling its closest global competitor by 77.06% of worldwide sales in 2021 (Dean, 2022). Tesla's data is also readily available compared to other EV companies that might not have fully released data to the public. The global electricity usage for transportation is used as an independent variable to provide an outlook on how the demand for electricity in transportation can affect global CO2 emission. Global CO2 emission from passenger cars can give us an outlook on how changes within the emission of the transportation sector affect the total CO2 emission worldwide.

Analysis Method Used

Figure 6

Compiled Data of total CO2 Emissions, Global Electricity consumption for Transportation, and Units sold by Tesla

Year	Global CO2 Emission (Billion tonnes)	Energy consumption (EJ)	Global Tesla Sales (Units)
1990	22.75	0.9	0
1991	23.24	0.9	0
1992	22.57	0.8	0
1993	22.80	0.8	0
1994	22.96	0.8	0
1995	23.45	0.8	0
1996	24.15	0.8	0
1997	24.30	0.8	0
1998	24.21	0.8	0
1999	24.52	0.8	0
2000	25.23	0.8	0
2001	25.45	0.8	0
2002	26.04	0.8	0
2003	27.37	0.9	0
2004	28.63	0.9	0
2005	29.60	0.9	0
2006	30.58	1	0
2007	31.49	1	0
2008	32.07	1	0
2009	31.61	1	0
2010	33.34	1.1	0
2011	34.47	1.1	0
2012	34.97	1.1	2600
2013	35.28	1.2	22400
2014	35.53	1.2	32000
2015	35.50	1.2	50000
2016	35.45	1.3	76200
2017	35.93	1.3	103100
2018	36.65	1.4	245200
2019	36.70	1.5	367500

30 data observations of each variable are collected and compiled into a single excel sheet and regression analysis is used to test the impact of each independent variable on the dependent variable of total CO2 emission. The data range from the year 1990 to 2019, a period of 30 years. The units of global CO2 emission, energy consumption, and Tesla sales are in billion tonnes, exajoules (EJ), and units respectively.

Regression equation: Global CO2 emission = $\beta_0+\beta_1$(Global electricity consumption)+ β_2(Global EV sales)+Residual

Figure 6

Regression Analysis

SUMMARY OUTPUT								
Regression Statistics								
Multiple R	0.952555096							
R Square	0.90736121							
Adjusted R Square	0.900499078							
Standard Error	1.642415895							
Observations	30							
ANOVA								
	df	*SS*	*MS*	*F*	*Significance F*			
Regression	2	713.3741707	356.6870854	132.2272927	1.12643E-14			
Residual	27	72.83330929	2.697529974					
Total	29	786.20748						
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95.0%*	*pper 95.0%*
Intercept	-0.637800697	2.150451833	-0.296589157	0.769049754	-5.050163393	3.774562	-5.05016	3.774562
Energy consumption (EJ	30.95763329	2.281771169	13.56736982	1.42345E-13	26.27582558	35.63944	26.27583	35.63944
Global Tesla Sales	-2.61042E-05	5.81834E-06	-4.486536422	0.000120979	-3.80425E-05	-1.4E-05	-3.8E-05	-1.4E-05

Conclusion

By running regression analysis, we found that both independent variables were statistically significant as the P-values were all below the significance level of 0.05. Therefore, we can be certain that both factors play a big role in the total carbon emissions of each country. Having said that, the impact of energy consumption on total CO2 emissions is over a million times greater than the impact of EVs on CO2 emissions. This proves that the adoption rate of EVs as of now will not be able to overcome the negative impacts of energy consumption. With the proposed data collection, a more accurate analysis can be done on this matter. EVs have also only been around for slightly over 10 years. Only recently has there been a major increase in EV sales. Research over a longer period is required to assess the full impact of EVs, but as of now, with the data that is currently present, EVs do not seem to be the be-all and end-all answer to global warming.

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