
Electric Vehicle Incentives Analysis

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Objectives

We wanted to discover how effective the Incentives for Zero-Emission Vehicles (iZEV) program has been at encouraging Canadian consumers to purchase electric vehicles as apposed to traditional ones. The data that we were interested in analyzing were data related to the number of vehicles registered in Canada in the years before and after the IZEV program was intruduced. We also wanted to look at how popular the iZEC program is, how much it has been used and how the incentives offered through the program have been related to the change in vehicle registrations.

After obtaining the data, we wanted to analyze it to determine whether or not the incentives have been successful at playing a significant role in the change in electric vehicle purchasing trends. Ideally it would be possible to use hypothesis tests to determine the likelihood of iZEV incentives causing an increasing in electric cehicle purchases by comparing the purchasing behaviour before and after the incentives became available.

Data Preparation


Data about new vehicle registrations in Canada was retrieved from Statistics Canada. The data included the number of vehicle registrations in each province, for the years 2017-2022, sorted by vehicle type. Data was not available for Alberta, Newfoundland or New Brunswick. The data was downloaded as a .csv file from the Statistics Canada website¹.


Data related to the economic incentives granted by the iZEV program was also retrieved from the government of Canada's Open Government Portal. The data summarizes all instances of incentives received by consumers, sorted by province and vehicle type. The data was also downloaded as a .csv file from the Government of Canada Open Government website².

In order to standardize the registrations and incentives, since the different provinces were going to be used as data points, the populations of the provinces was retrieved from Wikipedia³.

The data was wrangled in order to produce a table where each observation represents one province for one year. Because each province has significantly different populations, new variables were introduced. A variable for the fraction of all vehicle registrations that were electric vehicles was calculated, as well as a variable representing the number of registrations per capita. The final dataframe can be seen below in the [Appendix: Data Samples](#)

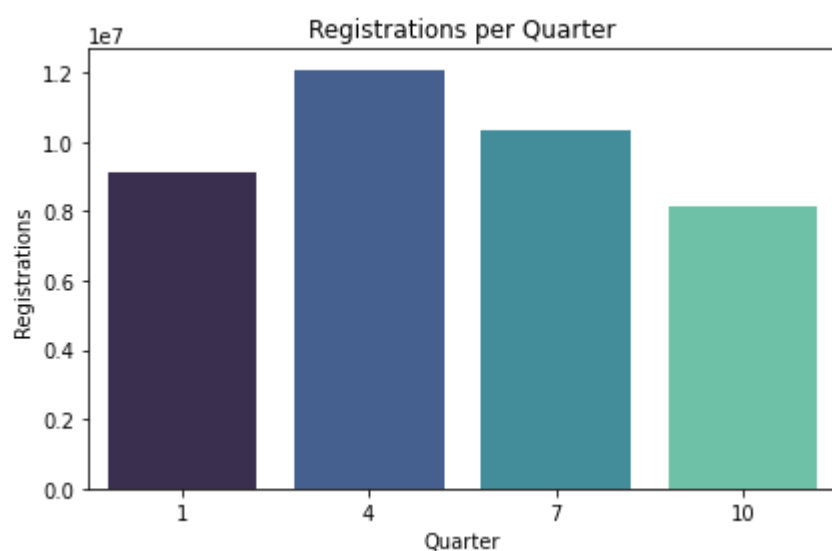
The data for each year were not all complete, so the final values had to be changed to compensate. The vehicle registrations data was missing the last two quarters of 2022, and the financial incentives data was missing the first four months of 2019, and the last 3 months of 2022. We examined if there were any patterns in vehicle registrations and iZEV incentives received from the complete years in order to determine how to recalculate the values for 2019 and 2022. Below are plots of the distributions of registrations per quarter, and incentives per months. Because of the general pattern of increased registrations and incentives during the middle of the year, the values for the registrations in the final data set were adjusted to compensate for this relationship. Below are the results of an ANOVA test for the registrations and the incentives, and it can be seen that in the case of the registrations, there is a significant result that the quarters are not identical, and therefore the values were used to compute the final values, whereas the incentives were treated as if the months were identical.

1. Government of Canada, Statistics Canada. (2022, October 11). New Motor Vehicle Registrations, quarterly. Government of Canada, Statistics Canada. Retrieved December 9, 2022, from <https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=2010002401> 

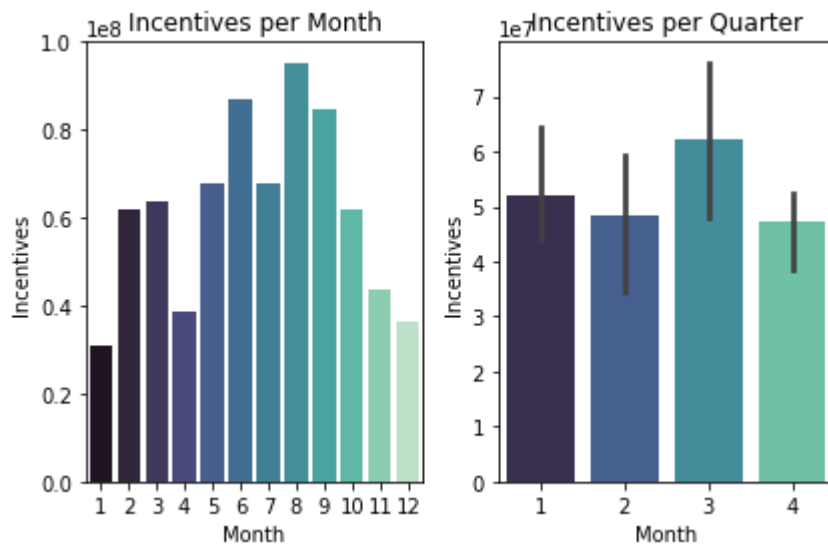
2. Statistics on the incentives for zero-emission vehicles (iZEV) program - statistics on the incentives for zero-emission vehicles program (iZEV) - Data Dictionary. Open Government Portal. (n.d.). Retrieved December 9, 2022, from <https://open.canada.ca/data/en/dataset/42986a95-be23-436e-af15-7c6bf292a2e1/resource/12a8a111-d790-49ce-af7c-ec388345e147> 

3. Wikimedia Foundation. (2022, October 19). Population of Canada by province and territory. Wikipedia. Retrieved December 9, 2022, from https://en.wikipedia.org/wiki/Population_of_Canada_by_province_and_territory 

	sum_sq	df	F	PR(>F)
REF_DATE	8.450503e+09	1.0	3.912846	0.047963
Residual	1.329932e+13	6158.0	NaN	NaN

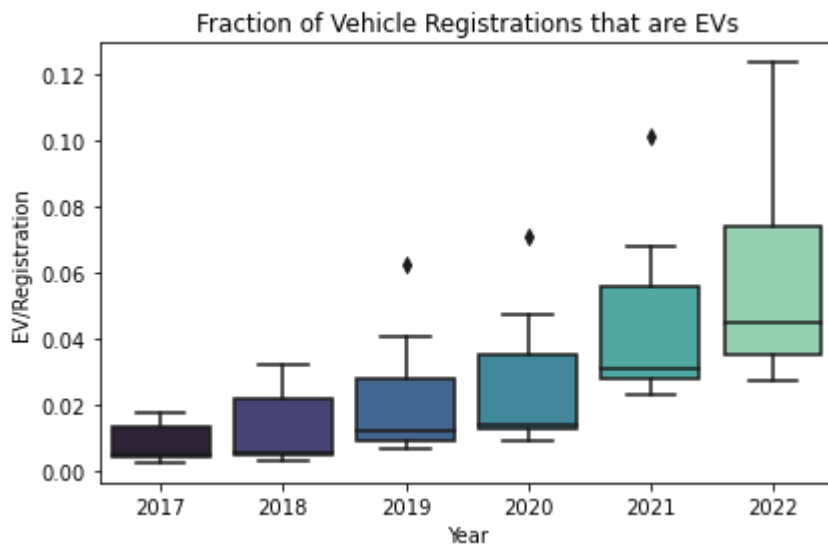


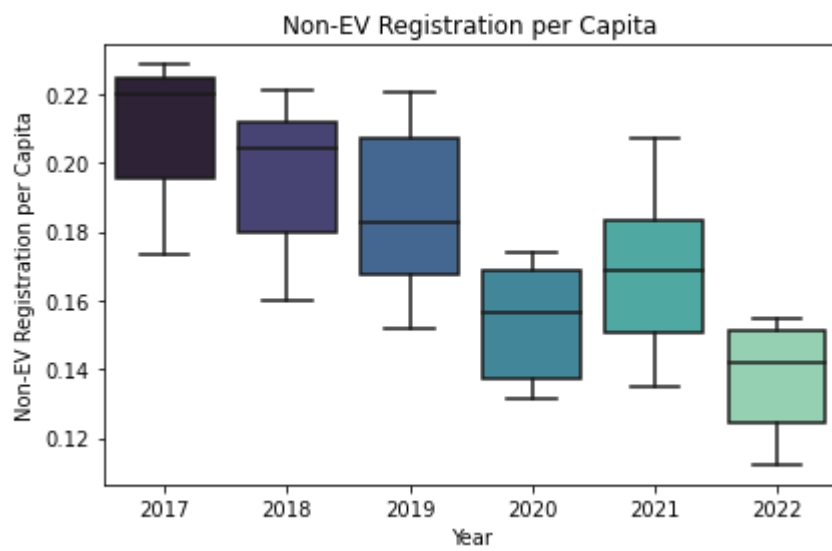
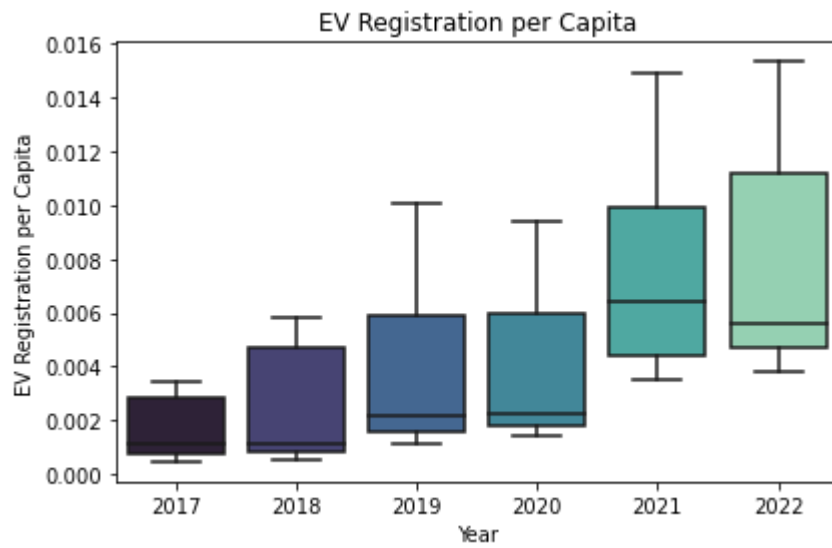
	sum_sq	df	F	PR(>F)
Quarter	1.914295e+12	1.0	0.009501	0.923959
Residual	2.417717e+15	12.0	NaN	NaN



Initial Analysis

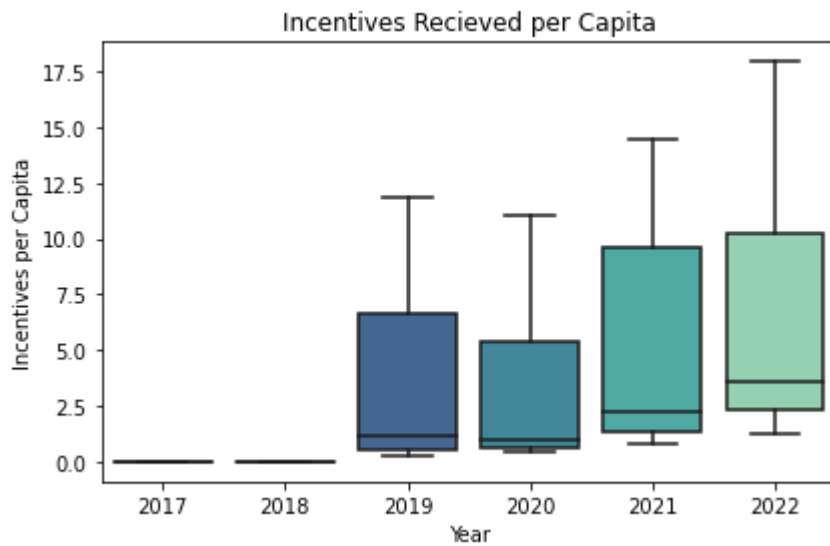
The first step in the analysis was to examine the trends that took place over the 2017-2022 period that was being examined. By looking first at the change in the fraction of vehicle registrations that are EVs, and the EV and non-EV registrations per capita, several trends become clear. Not only has the fraction of vehicles that are EVs consistently been increasing, but the raw number of EV registrations per capita has been increasing, while the non-EV registrations have been decreasing. It can be seen there is a clear trend towards more EV registrations and a higher fraction of EV vehicles.





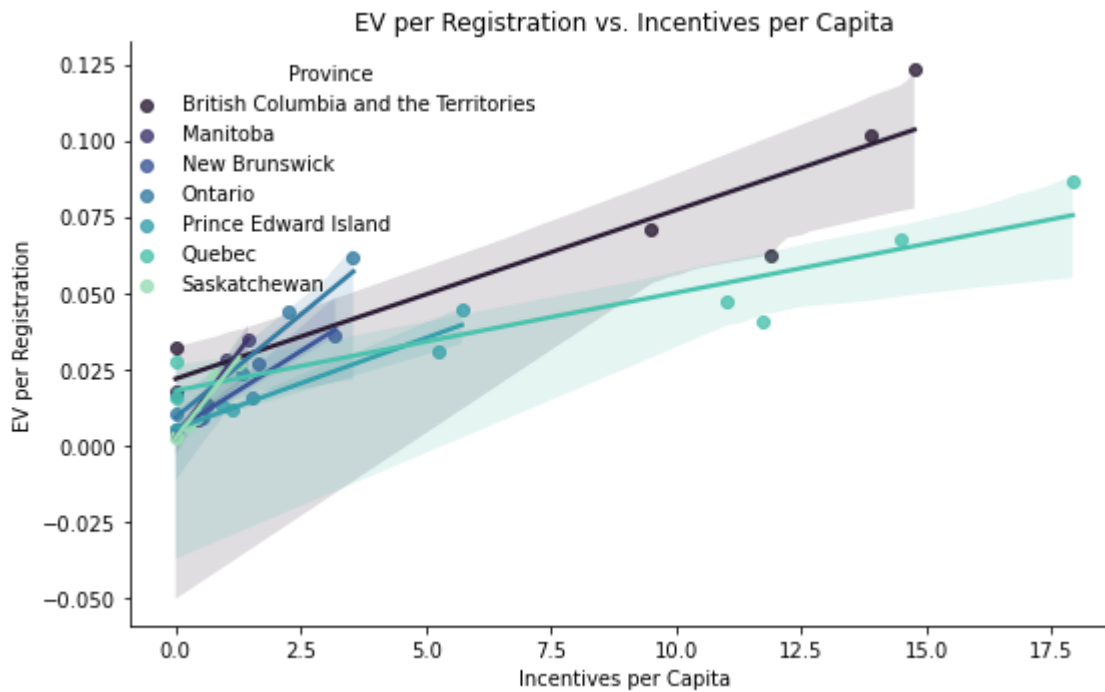
We can also see that the total incentives recieved has not remained constant after they were initially implemented, as an ANOVA test shows that they are unlikely to have the same mean.

	sum_sq	df	F	PR(>F)
Year	0.000086	1.0	5.508144	0.026821
Residual	0.000404	26.0	NaN	NaN



Linear Regression

If we examine linear plots of the fraction of EV registrations compared to incentives per capita, we can see that there is a strong linear relationship between the two. There is an even stronger linear relationship between the EV reigstrations per capita and the incentives per capita, but this is not a very surprising result: the EV registrations per capita must increase with the incentives per capita because the incentives can only increase when people buy (and then register) an electric vehicle, but it is not so straightforward that the incentives should scale with the EV fraction. This relationship suggests that as more people purchase electric vehicles and recieve incentives for them, EV vehicles are simultaneously becoming more popular relative to conventional vehicles.



OLS Regression Results

Dep. Variable:	EV/Reg	R-squared:	0.775
Model:	OLS	Adj. R-squared:	0.769
No. Observations:	42	F-statistic:	137.7
Covariance Type:	nonrobust	Prob (F-statistic):	1.58e-14

	coef	std err	t	P> t	[0.025	0.975]
const	0.0132	0.003	5.278	0.000	0.008	0.018
Inc/Pop	0.0049	0.000	11.734	0.000	0.004	0.006

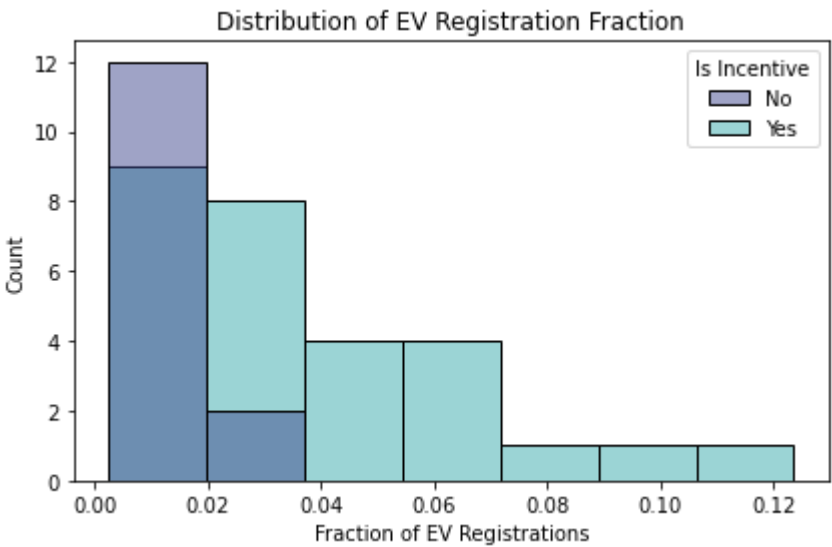
Notes:

[1] Standard Errors assume that the covariance matrix of the errors is correctly specified.

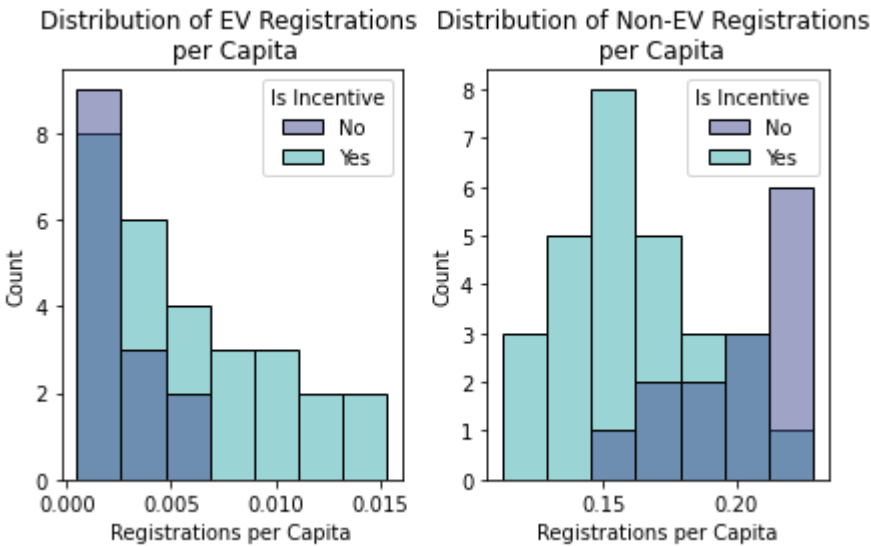
Hypothesis Testing

If we compare the distributions of EV and non-EV vehicles per capita registration, depending on whether they were registered during a period of time that the iZEV incentives were in place, it is possible to see that EV registrations are higher after the incentives came into place, and non-EV registrations were lower. This all

combines to give us some motivation to determine if the incentives were specifically influenced by the iZEV incentives. The below t-tests show that there is a significant difference in the mean of the fraction of EV registrations before and after the incentives with an $\alpha = 0.05$. There is also significant result showing an increase in the EV registrations per capita, and a decrease in the non-EV registrations per capita over the same time periods.



	T-test Statistic	p Value
0	3.343128	0.001807



	T-test Statistic	p Value
0	3.147916	0.003104

	T-test Statistic	p Value
0	-4.796601	0.000023

However, looking at year-to-year comparisons instead of simply comparing the before and after periods shows that there is no significant difference in the jump from 2018 to 2019 - or in an individual year - which casts doubt on the idea that the iZEV incentives are specifically responsible for the difference noted above, instead of simply the trend of increased popularity of EV that can be seen in the yearly registration data.

	Years	p Value of T-test
0	2017-2018	0.345220
1	2018-2019	0.368296
2	2019-2020	0.680797
3	2020-2021	0.200511
4	2021-2022	0.459965

	Years	p Value of T-test
0	2017-2018	0.394222
1	2018-2019	0.407797
2	2019-2020	0.983043
3	2020-2021	0.114218
4	2021-2022	0.851350

Conclusions

While it is certainly the case that electric vehicles have increased in popularity over the years from 2017-2022, and there is a correlation between the increase and the iZEV incentive program, there does not appear to be strong evidence that the incentive program itself had a significant effect. If it had had an effect, we would probably expect to see a particularly large increase in EV registrations in the year or two after they came into effect, and while there is an increase, there does not seem to be anything special about the jump from 2018-2019.

Appendix: Data Samples

	Province	Year	Type	Registrations	Population	Reg/Pop	Total Incentive	Is Incentive	Inc/Pop	EV/Reg
0	British Columbia and the Territories	2017	EV	16888.0	5082181	0.003323	0.000000e+00	No	0.000000	0.017339
1	British Columbia and the Territories	2017	Not EV	973984.0	5082181	0.191647	0.000000e+00	No	0.000000	0.017339
2	British Columbia and the Territories	2018	EV	28828.0	5082181	0.005672	0.000000e+00	No	0.000000	0.032335
3	British Columbia and the Territories	2018	Not EV	891544.0	5082181	0.175425	0.000000e+00	No	0.000000	0.032335
4	British Columbia and the Territories	2019	EV	51156.0	5082181	0.010066	4.532182e+07	Yes	11.890387	0.062321
	Province	Year	Type	Registrations	Population	Reg/Pop	Total Incentive	Is Incentive	Inc/Pop	EV/Reg
79	Saskatchewan	2020	Not EV	177132.000000	1132505	0.156407	449374.999988	Yes	0.396797	0.009055
80	Saskatchewan	2021	EV	4014.000000	1132505	0.003544	875000.000000	Yes	0.772624	0.022892
81	Saskatchewan	2021	Not EV	175342.000000	1132505	0.154827	875000.000000	Yes	0.772624	0.022892
82	Saskatchewan	2022	EV	4326.815478	1132505	0.003821	955000.000000	Yes	1.264895	0.026940
83	Saskatchewan	2022	Not EV	160607.803536	1132505	0.141816	955000.000000	Yes	1.264895	0.026940