In the Early 1980s, Unemployment and Inflation Rates were Strongly Correlated to Low Automobile Sales, but Skyrocketing Oil Prices were not*

Tim Stephens

23 April 2021

Abstract

Canadian automobile sales have been historically strong but were decimated in the early 1980s. Multiple oil crises in the 1970s led to skyrocketing oil prices, a global recession, and ultimately, high unemployment and inflation rates for Canadians. This paper will inspect the relationship between oil prices, unemployment, inflation, and automobile sales using regression discontinuity design, linear regression, and multiple linear regression. It was found that unemployment and inflation rates had a strong correlation with automobile sales, but oil prices did not. By understanding why automobile sales were low in the past, companies (and the Canadian economy) can prepare for dips in sales by monitoring different socioeconomic factors.

Keywords: Automobile, Car, Canada, Unemployment, Inflation, Oil, Sales, Economy

*Code and data are available at: https://github.com/tim-stephens/Historic-Car-Sales-in-Canada.git.

Contents

1.0 Introduction

1.1 History and Importance of the Automobile Industry in Canada

Canada has a rich automotive history that is deeply connected to its economy. Canada welcomed the creation of Ford Motor Company of Canada Ltd in 1904 and is now home to many other manufacturing plants such as General Motors, Toyota, Honda, and Fiat-Chrysler (Ruppenthal and Bonikowsky (2006), Government of Canada (2019)). These plants make massive contributions to Canada's manufacturing sector, representing 12% of manufacturing gross domestic product (GDP) and 24% of manufacturing trade (Ruppenthal and Bonikowsky (2006)). The industry itself employs roughly 130,000 people, mostly located in Ontario, and indirectly employs another 370,000 (Canadian Vehicle Manufactuer's Association (2021)). Canada is a significant competitor in the global automobile market. It is the eighth largest producer of vehicles and the third largest exporter after Japan and the US (Ruppenthal and Bonikowsky (2006)). Every year, Canada exports $65 and $30 billion worth of vehicles and parts, respectively (Ruppenthal and Bonikowsky (2006)).

Although 80% of vehicles produced in Canada are exported (Ruppenthal and Bonikowsky (2006)), there are still roughly 35 million registered vehicles in Canada (StatsCan (2021)). This is nearly one vehicle for every Canadian and shows that the domestic market is still making significant contributions to the Canadian economy. Since the beginning, there has been consistent growth in national sales for the Canadian automobile industry – with a few exceptions (Development and Trade (2013)). In the early 1980s, there was a dramatic decrease in the number of new vehicles sold in Canada (Development and Trade (2013)).

Because the automotive sector is such a large contributor to the Canadian economy, governments and manufacturers need to be able to predict sales to ensure the right number of vehicles are produced. If too many vehicles are made, dealership lots will be full, cars will be wasted, and prices will drop. This will result in huge financial losses for the companies and could impact their choice to produce vehicles in Canada. Governments need to be able to predict contributions to the economy so that if sales drop, changes can be made to cover for the loss in economic output. By monitoring different socioeconomic factors, governments and companies should be able to develop models to predict sales. There are many factors that affect the number of vehicles sold in a country, but this paper will argue that high oil prices, unemployment rates, and inflation were related to the dramatic decrease of Canadian automobile sales during the early 1980s.

1.2 Important Events in the 1970s and 1980s

The 1970s experienced two significant oil crises, the second of which contributed to a global recession (Kose, Sugawara, and Terrones (2020)). In 1973, Egypt and Syria launched an attack on Israel (History.com Editors (2010)). The Soviet-Union supported the attackers and the US backed Israel (History.com Editors (2010)). As an act of retaliation, the Organization of Arab Petroleum Exporting Countries significantly reduced their oil production and created an oil embargo on the US (History.com Editors (2010)). This ban on trade and reduced production dramatically affected the price of oil, from $2.70 USD per barrel in 1973 to $11.00 in 1974 (Organization of the Petroleum Exporting Countries (2021)). Although the trade ban was lifted in 1974, the price of oil stayed relatively high and did not fall back to pre-embargo levels (Organization of the Petroleum Exporting Countries (2021)).

In 1979, the second dramatic increase in the price of oil occurred. The Iranian Revolution started in 1978 and ended in 1979 with the Shah of Iran being ousted by Ayatollah Khomeini (Sawyers (2013), Downey (2020)). Khomeini drastically reduced oil production, which reduced global shipments of crude oil (Sawyers (2013)). Due to the reduced supply, gasoline prices skyrocketed. Prices more than doubled from 1978 - 1979, from $12.79 USD per barrel to $29.19 (Organization of the Petroleum Exporting Countries (2021)).

Partly because of the dramatic increase in the price of oil, Canada was plunged into a deep recession during the early 1980s. The Iranian Revolution, paired with new monetary policy, led to a sharp decline in US production and an increase in unemployment rates (Kose, Sugawara, and Terrones (2020)). Since the US and Canadian economies were so tightly linked, Canadians felt the impact of the US' decreased production and saw a dramatic increase in the unemployment rate as well. In 1981, unemployment was at

7.6%, but by 1982, this number had jumped to 11.0% (Statistics Canada (2021)). As the CBC said, "If they're not building homes in Boston, they're not cutting timber in BC" (Mansbridge and Duffy (1983)). The increase in price of oil and new monetary policy eventually led to increasing rates of inflation around the world – including Canada (Kose, Sugawara, and Terrones (2020), Inflation.eu (2021)). Currently, the Bank of Canada tries to keep inflation between 1 and 3% (Canada (n.d.)). In the early 1980s, inflation was at just over 12% (Inflation.eu (2021)). Combining the high inflation rate with a high unemployment rate meant Canadians were having difficulty purchasing groceries, heating their homes, and financing significant life events (Mansbridge and Duffy (1983)). Without money for food, it is unlikely that many Canadians were considering purchasing new automobiles at this time.

1.3 Structure of paper and method of analysis

This paper will try to confirm the research above using datasets provided by various sources, which are discussed in the next section. A surface level investigation into Canadian automobile sales, world oil prices, Canadian unemployment rates, and Canadian inflation levels will be done next. After, four regression discontinuity design (RDD) models will be constructed to observe the dip in sales during the early 1980s. Three separate linear regression models will then be constructed with vehicle sales as the dependent variable and oil prices, unemployment rate, and inflation rate used as the independent variables. A multiple linear regression model will also be created. The paper will then discuss results, key findings, ethics, weaknesses, and some next steps. Although this study looks to draw a link between vehicle sales, oil prices, unemployment rates, and inflation, it will not be able to speak to causality. The reasoning behind why causality cannot be determined will be talked about in the discussion section, after key findings.

2.0 Data

2.1 Datasets used

In this analysis, four datasets were used. First, the "New Motor Vehicle Sales" dataset was used to determine the number of new vehicles sold in Canada (Development and Trade (2013)). Published by the Government of Alberta, this dataset records monthly provincial and national vehicle sales as far back as 1946; however, provincial data was not available until 1968. It was last updated in 2015, but the year was not complete. To allow for overlap with other datasets, only national data from 1960 to 2014 were included and monthly vehicle sales were converted to yearly sales. This data comes from a reputable source, but only recorded new vehicle sales. Used automobile sales and gifted vehicles were not included in this analysis.

The second dataset was for historical oil prices from 1960 to 2021 (Organization of the Petroleum Exporting Countries (2021)). The dataset was pulled from Statista and was published by Mineralölwirtschaftsverband (MWV), a German company which "[represents] the petroleum industry in legal matters, particularly in the preparation of laws and regulations" (Pipeline Technology Conference (2021)). MWV monitors world oil prices, particularly the price of crude oil from the Organization of the Petroleum Exporting Countries (OPEC). To fit with other data used in this study, only the years 1960 to 2014 were selected. There were some discrepancies between this dataset and the study. This dataset monitors the oil price from OPEC – not historic Canadian prices. Unfortunately, data on historical Canadian oil prices (within the right time frame) could not be found. Regardless, trends are related between the two, and OPEC prices will hold as a valid substitute.

The third dataset used for this analysis was for Canadian unemployment rates (Statistics Canada (2021)). The dataset was published by Statistics Canada, drawing on information learned from labour force surveys. Information from 1976 - 2018 was collected, which was all that was available. The original dataset was large, holding information about the entire labour force. It was trimmed so that only national unemployment rates were selected. In terms of demographics, unemployment rates for both sexes above the age of 15 were selected.

This was chosen to get a good idea of how Canada's labour force was functioning at the time of interest. It is noted, though, that it is unlikely that a 15-year-old would purchase a new vehicle.

The last dataset was created by the analyst. Data was pulled from inflation.eu (Inflation EU (2021a)). Inflation.eu "contains current and historic data about inflation and the consumer price index", citing Statistics Canada as its source for Canadian data (Inflation EU (2021b)). Data was copied from the historic data web page into a csv file in order to run the analysis.

2.2 How Data was Analyzed

Data was analyzed using R(R Core Team (2020)). Many packages were used to study the data, with tidyverse doing much of the heavy lifting (Wickham et al. (2019)). Janitor (Firke (2021)) was used to clean datasets. Here (Müller (2020)) helped in locating and saving files. Ggplot2 (Wickham (2016)), gridExtra (Auguie (2017)), and huxtable (Hugh-Jones (2021)) were used to create graphs, figures, and tables. Tinytex (Xie (2021)) was used to help write the output to PDF and bibtex (Francois (2020)) was used for citations.

2.3 Show me the money!

First, Canadian automobile sales were investigated. Figure 1 shows new yearly car sales in Canada from 1960 to 2014.

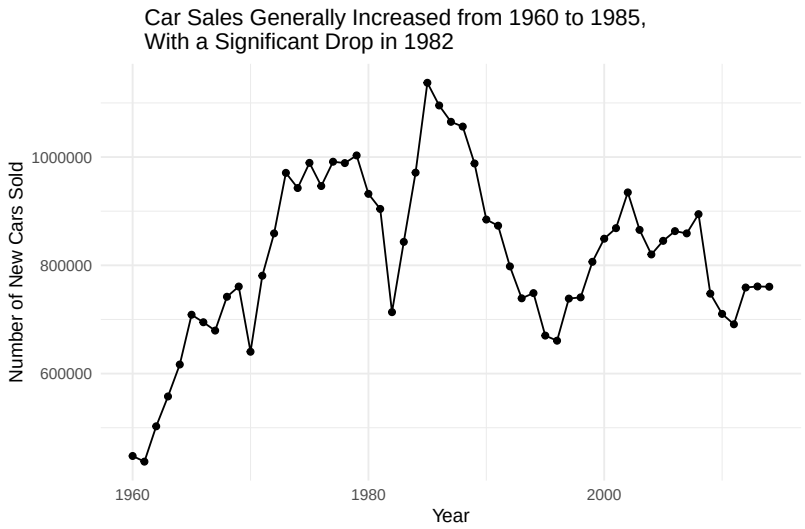

Figure 1: Historical Car Sales in Canada

Figure 1 shows car sales generally increased from the period of 1960 to 1985, with a few dramatic drops in sales. There was a decrease in 1970 and in the early 1980s, but the drop in the '80s was much more dramatic. This is the area of interest for the study. After 1985, sales started to decrease until the mid 1990s, when sales slowly started to increase again. Sales leveled out for a few years, but eventually decreased just before 2010. This drop in sales could be attributed to the stock market collapse of 2008 but falls outside the scope of this study. Figure 2 shows Canadian truck sales between 1960 and 2014. The trend is more positive than that of Figure 1.

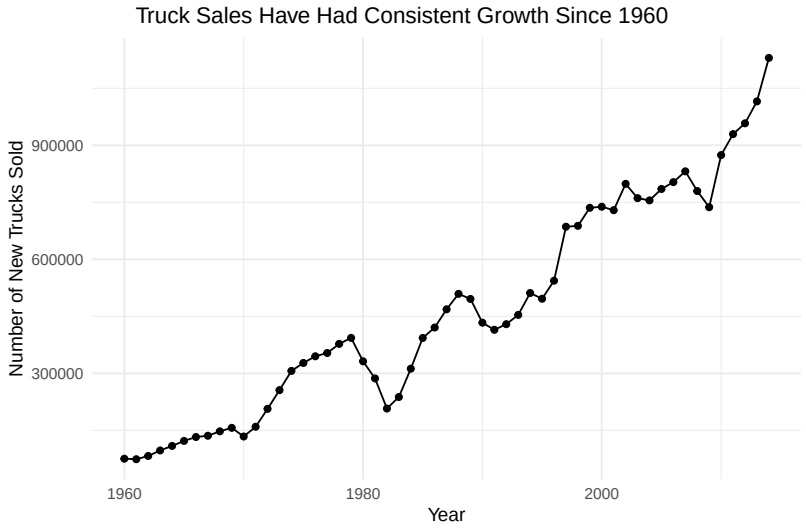

Figure 2: Historical Truck Sales in Canada

Canadian truck sales have done significantly better than Canadian car sales (Figure 2). The trend has been overwhelmingly positive, and the market has steadily grown since 1960. Although the market did have dips in sales at the same time as car sales (1970, early 1980s, 1990s, and just before 2010), the changes are not as dramatic. The truck market is apparently less volatile than the car market in Canada. However, the number of new trucks sold is not as high as the number of new cars sold. The market is smaller, but more stable. Although comparing the Canadian car and truck markets is interesting, the total number of vehicles sold in Canada was used for this analysis. Figure 3 shows the combined sales of cars and trucks.

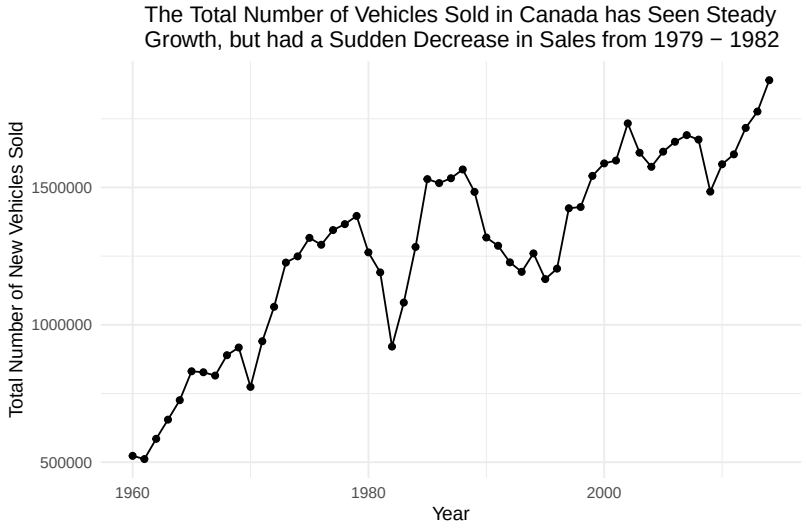

Figure 3: Historical Total Automobile Sales in Canada

The combined plot in Figure 3 looks as one might expect: similar to the car sales plot, with less dramatic peaks and troughs. The truck sales have made the market less volatile. For the rest of this paper, this will be the dataset used when discussing vehicle sales in Canada. Generally, sales have increased but saw a dramatic decrease from 1979-1982. Now that vehicle sales are known, independent variables of interest were selected to

see if they were related to sales. The first is historic oil prices. Although Canadian oil prices could not be found in the correct time frame, world oil prices follow similar trends, and will be sufficient for this study. Figure 4 shows historic oil prices of OPEC crude oil.

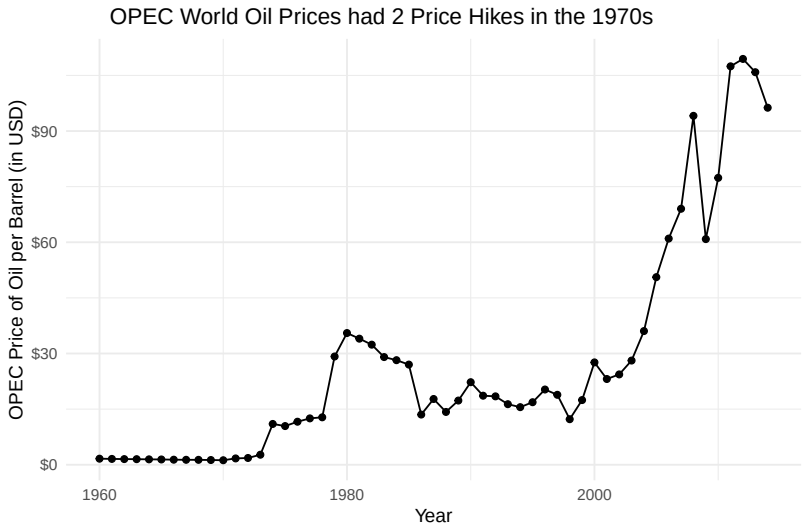

Figure 4: Historical Oil Prices

As discussed in the introduction, world oil prices saw two significant increases in the 1970s. Figure 4 shows that the first price hike was between 1973 and 1974, and the second was between 1978 and 1979 – although prices peaked in 1980. After that, oil prices stayed relatively constant before deceasing between 1985 and 1986. Oil prices then remained stable before undergoing a period of dramatic increase starting around the year 2000. For the purposes of this study, the period of interest is the 1970s and early 1980s. The increase starting in the year 2000 will not be investigated. Another factor thought to affect new automobile sales was the unemployment rate. Trends for this variable are shown in Figure 5.

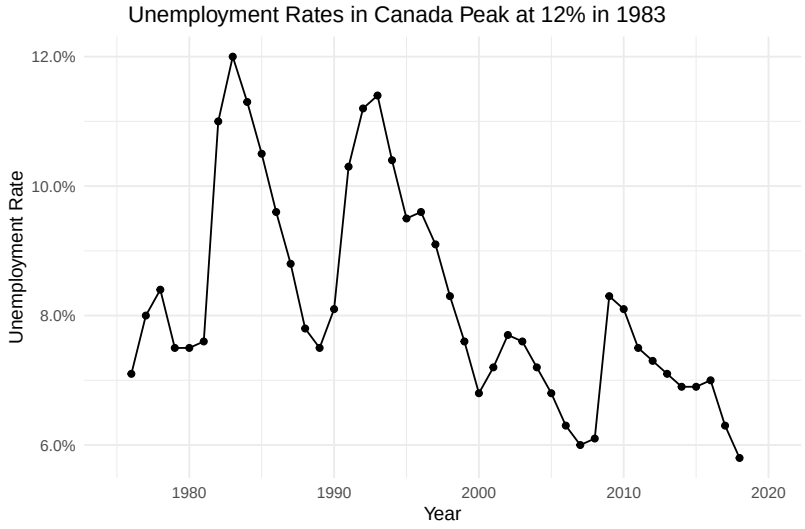

Figure 5: Unemployment Rates in Canada

Unemployment data was only available from 1976, so the x axis scale is different than Figures 1-4. Figure 5 shows that unemployment rates have fluctuated over time, and it is normal for countries to experience periods with high unemployment. There were two dramatic peaks for Canadians: 1983 and 1993. 1983 saw the highest unemployment rate at 12%, but unemployment was also very high in 1982. This is an extremely interesting point, as it falls within the scope of the study. The last variable of interest was inflation rate. Historic levels are shown in Figure 6.

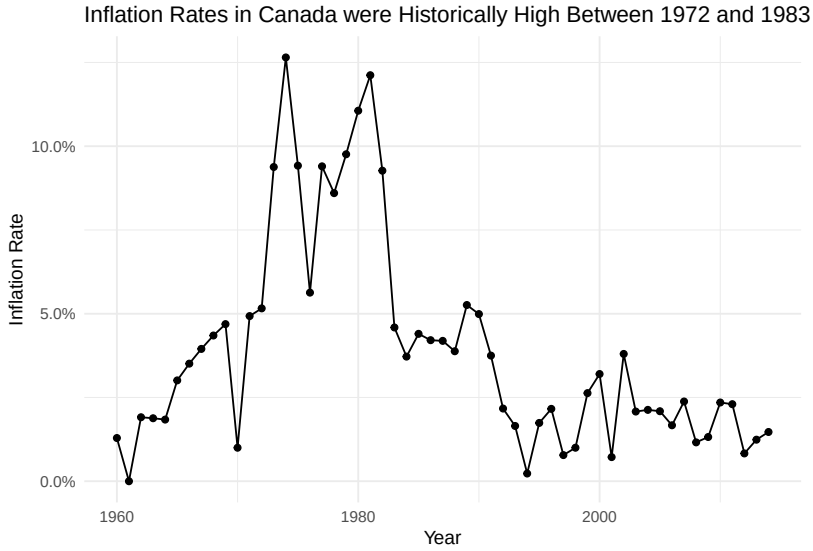

Figure 6: Inflation Rates in Canada

As stated in the introduction, the Bank of Canada tries to keep inflation between 1 and 3%, which can be seen in Figure 6 from 1991 onward. Before then, inflation seemed to run wild, peaking in 1974 with inflation at 12.65% (Inflation EU (2021a)). Inflation was also very high during the period of interest, with inflation at 12.12% in 1981 (Inflation EU (2021a)). To easily compare all variables, Figure 7 was created. It shows the total number of vehicle sales, world oil prices, unemployment rates, and inflation rates.

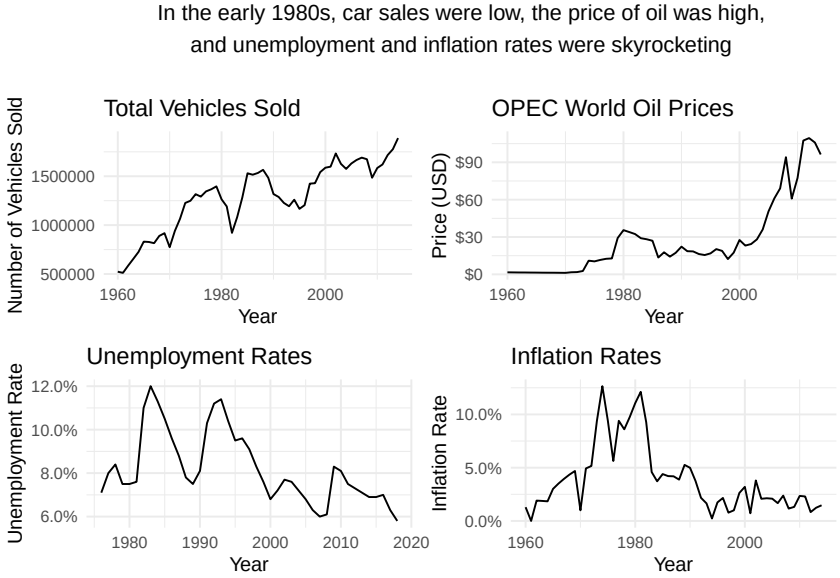

Figure 7: Total Automobile Sales, Oil Prices, Unemployment Rates, and Inflation Rates

Figure 7 shows some preliminary relationships. It appears that in the early 1980s, vehicle sales were low. At the same time, oil prices had seen a significant increase, unemployment rates were very high, and inflation rates were at just over 12%. With everything lining up, it seems as if all four of these variables were related in some way. To investigate the drop in vehicle sales, four RDD models were created. They are shown in the next section. Linear models were also constructed to determine if the four variables were statistically correlated.

3.0 Model

3.1 Regression Discontinuity Design

To further investigate the dramatic drop in sales during the early 1980s, four different RDD models were created. RDD models were selected for this study to help visualize the distinct drop in sales that occurred. Each model had year on the x axis and vehicle sales on the y axis. Each individual variable was inspected, and the year where the peak or trough occurred (within the time frame of the study) was chosen as the distinct cut-off point for the model. Oil prices peaked in 1980, unemployment rates were highest in 1983, inflation was high in 1981, and vehicle sales were lowest in 1982. Figure 8 shows an RDD model with 1980 as the cut-off, representing the year when oil prices were relatively high.

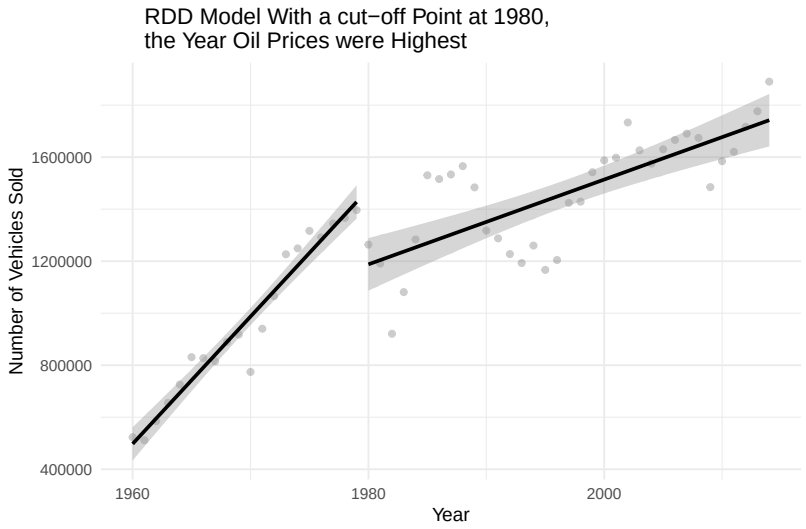

Figure 8: RDD for Oil Prices

The RDD model with 1980 selected as a cut-off point (Figure 8) shows a distinct drop in automobile sales. The light grey bars represent error, and this plot does not have any overlap. This shows that the year of 1980 did have a significant drop in automobile sales when compared to pre-1980 levels. However, there were many factors at play during the year of 1980, so there is not enough evidence to show that oil prices alone are what caused a dramatic drop in sales. Another possible factor in the drop in sales was unemployment, which is inspected next. Figure 9 shows an RDD for the year unemployment was at its highest: 1983.

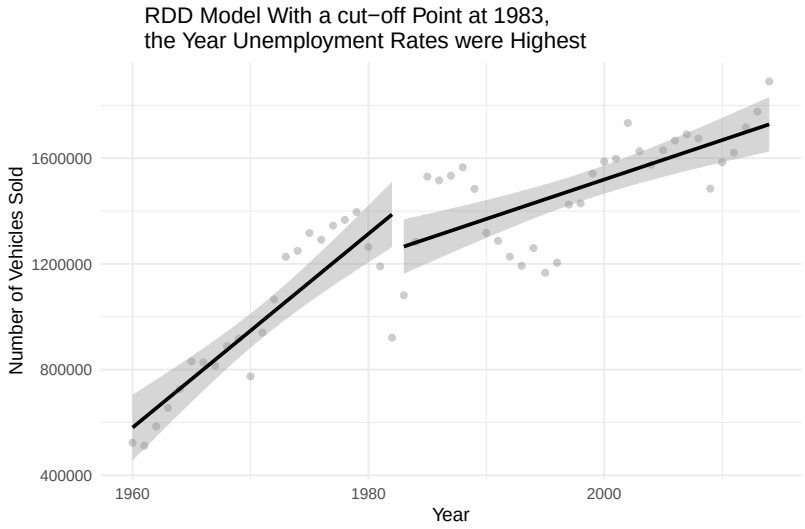

Figure 9: RDD for unemployment prices

Figure 9 shows a drop in sales during the year of 1983, but there is significant overlap in the error bars in this model. 1983 is not a good year to represent the dramatic drop in automobile sales in the early 1980s. After inspecting the dataset, it appears that automobile sales started to rebound in 1983. Nonetheless, the effects of unemployment on vehicle sales will still be inspected using a linear model in the following section. The next variable of interest is inflation, which had its highest value in 1981. Figure 10 shows an RDD model with 1981 as the cut-off point.

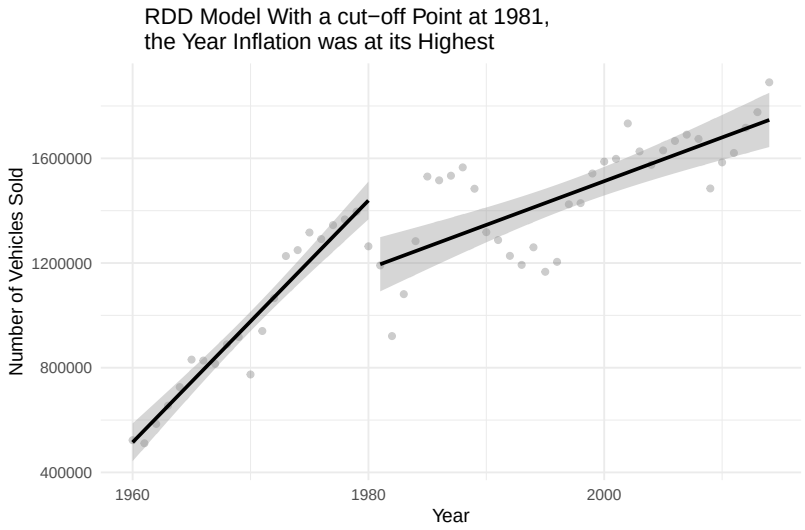

Figure 10: RDD for inflation

Figure 10 shows a significant drop in automobile sales during 1981, but there are many different factors at work behind the scenes, and it cannot be said with confidence that inflation is what caused the drop in sales. Nonetheless, the error bars do not overlap in this model, showing that the year of 1981 saw significant drops in automobile sales when compared to pre-1981 levels. The final RDD model was when vehicle sales were at their lowest: 1982. Figure 11 shows this model.

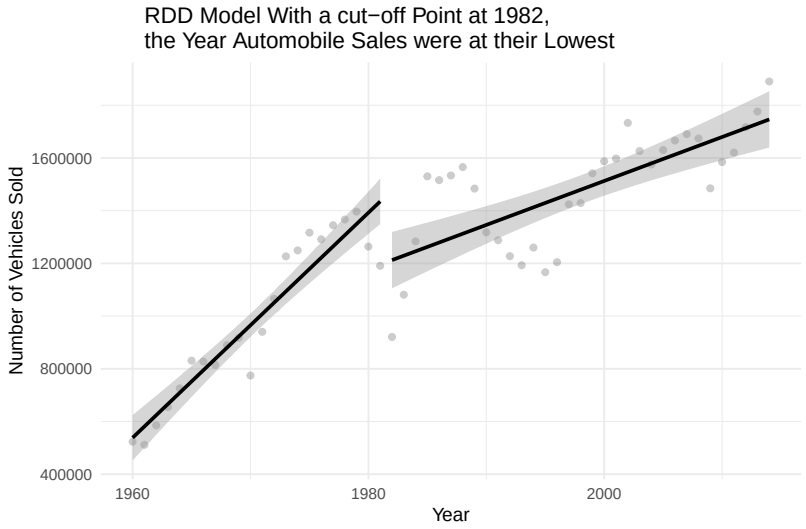

Figure 11: RDD for Sales

After selecting 1982 as the cut-off point in Figure 11, the results were similar to that of 1980 and 1981. The error bars do not overlap, and there is a significant drop in automobile sales. It is likely that all 3 factors contributed to this dramatic drop in sales in 1982. It is important to note that even though unemployment did not have a significant and clear finding, unemployment rates were high in 1982 as well. The auto industry had started to rebound by 1983, after a period of low sales. These different RDD models show that the years of 1980, 1981, and 1982 all saw a significant drop in sales when compared to pre 1980 levels. What caused the low sales cannot be determined with these RDD models, though, as they use year as the independent variable. A year itself cannot cause a drop in sales. Events that occurred during a given year are what give rise to change. A deeper discussion of causality will occur later in the paper. Linear models are developed in the next section to see if the variables are statistically correlated to sales.

3.2 Linear Models

In this section, three linear regression models and one multiple linear regression model were constructed. Linear models for each variable of interest were created to inspect their correlation to automobile sales. Then, all three were combined to increase the strength of the model, learn more about what was happening, and to account for any interaction between variables. Linear regression models were selected because of their ease-of-use, understandability, and ability to visualize relationships. The first linear model created was for oil prices. Figure 12 shows a visualization of the data, and Table 1 shows the linear regression results.

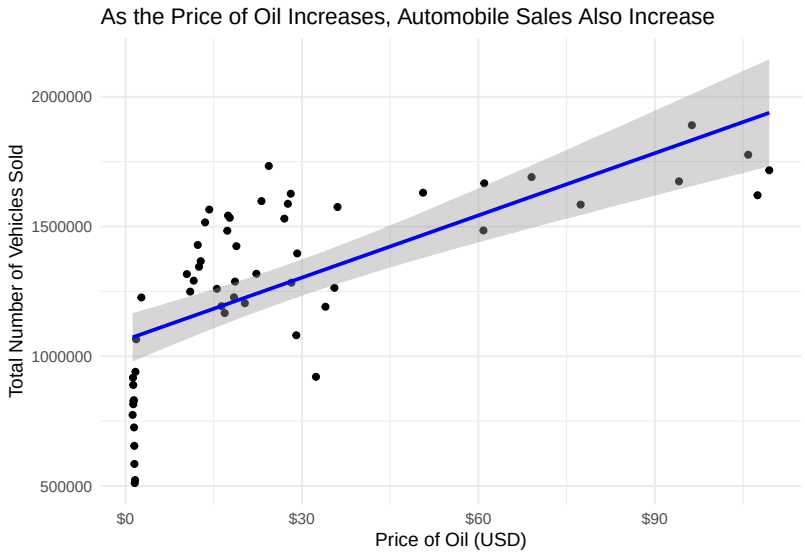

Figure 12: Linear Model for Oil and Auto Sales

Table 1: Linear regression of automobile sales and oil prices

Intercept	1063499.715 ***	(47452.091)
Oil Price (USD)	7991.364 ***	(1178.414)
Number of Observations	55	
R Squared	0.465	
P Value	0.000	
*** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$.		

Values in parentheses represent standard error

Interestingly, Figure 12 shows that oil prices are positively correlated with vehicle sales. Looking at the results of Table 1, for every one-unit increase in the price of oil, 7991 more cars will be sold! With a p value less than 0.001, this is a significant (and unexpected) finding, that contradicts the research done above. Even though car sales are positively correlated with oil prices, it is not a be-all-end-all finding. As stated in the introduction, the oil crisis of the late 1970s is what launched Canada into a recession, leading to increasing unemployment and inflation. To better the insights derived from this model, and to determine if any interaction between variables was occurring, a multiple linear regression model was also created to control for unemployment and inflation. Before building the multiple linear regression model, though, unemployment and inflation rates were inspected individually. The next linear model prepared was for of unemployment rates and total automobile sales. Results are shown in Figure 13 and Table 2.

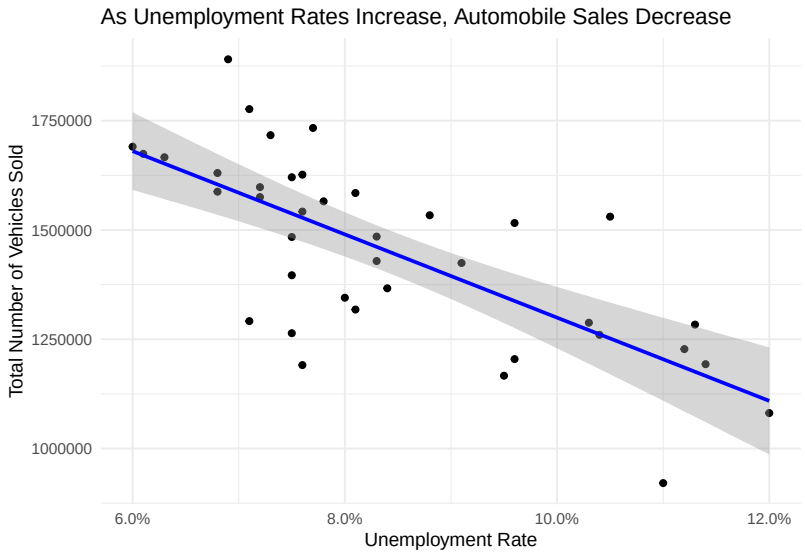

Figure 13: Linear Model for Unemployment and Auto Sales

Table 2: Linear regression of automobile sales and unemployment rates

Intercept	2251676.966 ***	(130575.988)
Unemployment Rate	-95225.039 ***	(15301.155)
Number of Observations	39	
R Squared	0.511	
P Value	0.000	
*** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$.		

Values in parentheses represent standard error

Figure 13 and Table 2 show a negative correlation between unemployment rate and automobile sales. Essentially, as unemployment rates rise, automobile sales are expected to fall. Table 2 show that for every one-unit increase in unemployment rate, 95,225 less vehicles will be sold. With a p value less than 0.001, this is a significant finding. Unemployment rate and vehicle sales are related. Further analysis will be done in the multiple regression to confirm this finding, and to check for any interaction between variables.

The final two-way relationship studied was inflation rate and sales. Data visualization is shown in Figure 14, and the linear model results are shown in Table 3.

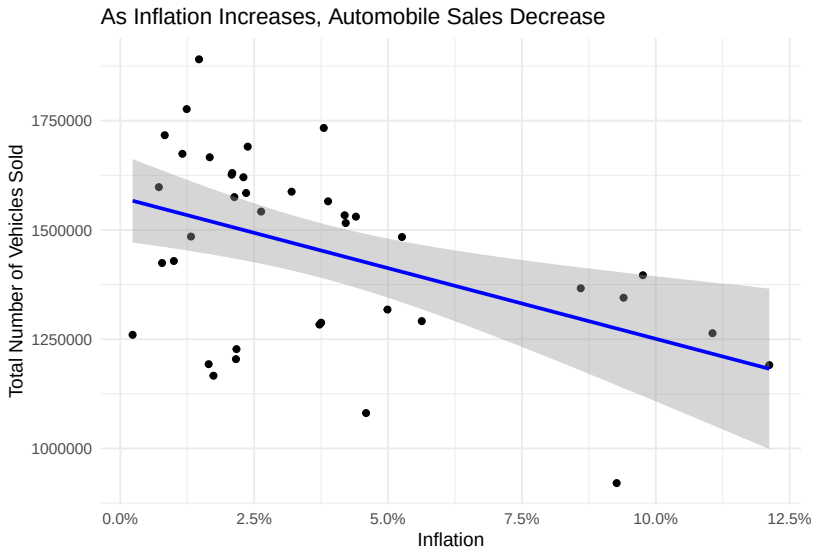

Figure 14: Linear Model for Inflation and Auto Sales

Table 3: Linear regression of automobile sales and inflation rate

Intercept	1574219.445 ***	(48941.113)
Inflation Rate	-32328.818 **	(10162.359)
Number of Observations	39	
R Squared	0.215	
P Value	0.003	
*** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$.		

Values in parentheses represent standard error

Figure 14 shows another negative correlation. As inflation rates rise, total new vehicle sales are expected to decrease. Specifically, Table 3 shows that for every one-unit increase in inflation rate, 32,329 less vehicles are expected to be sold. With a p value less than 0.01, this value is a significant finding. Inflation rates and vehicle sales are negatively correlated. This finding will be confirmed with the multiple linear regression model, which is prepared next. Interestingly, the results were not the same when compared to each individual model. Results are shown in Table 4.

Table 4: Multiple linear regression of automobile sales, oil prices, unemployment rate, and inflation rate

Intercept	2186875.303 ***	(134651.055)
Oil Price (USD)	1365.453	(749.913)
Unemployment Rate	-81744.565 ***	(13279.160)
Inflation Rate	-26579.921 ***	(6515.852)
Number of Observations	39	
R Squared	0.727	
P Value	0.000	
*** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$.		

Values in parentheses represent standard error

After creating a multiple linear regression model, some interesting findings appear (Table 4). With p values less than 0.001, unemployment rate and inflation are negatively correlated with total vehicle sales. However, the price of oil was no longer significantly related to automobile sales. A deeper discussion will occur in the next section, but it appears that oil prices are no longer a predictor of vehicle sales after controlling for unemployment and inflation.

4.0 Results

There were a lot of results in this analysis. First, it was found that the Canadian truck market was far less volatile than the Canadian car market. After combining the two into one sales figure, it was found that a significant drop in sales occurred in 1982. Next, three variables were inspected at the surface level: OPEC oil prices, unemployment rates, and inflation rates. It was found that all three had significant increases around the same time automobile sales plummeted (Figure 7). Next, four RDD models were created for each year the variable of interest had its peak (or trough). For oil prices, a cut-off point of 1980 was selected, unemployment rates had a cut-off of 1983, inflation was 1981, and automobile sales were 1982. There was clear separation for years 1980, 1981, and 1982, as there was no overlap of error bars. A small overlap occurred when 1983 was used, but automobile sales had started to recover after multiple years of low sales. The RDD models definitively showed that automobile sales saw a significant decrease in sales during the early 1980s but were starting to recover by 1983. It is likely that all three factors affected automobile sales, but the RDD models are unable to say why the drop in sales occurred. They can only show a significant drop in sales during a time period. A larger discussion of causality will occur in section 5.3.

Next, linear regression models were created to inspect correlation between variables. Initially, there was significant correlation for all three variables. Oil was positively correlated, and the other two were negatively correlated. However, when putting all three variables together into one multiple linear regression model, oil prices lost their significance. Why?

As discussed in the textbook "An Introduction to Statistical Learning with Applications in R" (James et al. (2017)), this is a common occurrence. A classic example has to do with temperature, sharks, and ice-cream sales. As stated in the textbook:

> Running a regression of shark attacks versus ice cream sales for data collected at a given beach community over a period of time would show a positive relationship, similar to that seen between sales and newspapers. Of course no one (yet) has suggested that ice creams should be banned at beaches to reduce shark attacks. In reality, higher temperatures cause more people to visit the beach, which in turn results in more ice cream sales and more shark attacks. A multiple regression of attacks versus ice cream sales and temperature reveals that, as intuition implies, the former predictor is no longer significant after adjusting for temperature (James et al. (2017)).

In the scenario of automobile sales, oil prices, unemployment rates, and inflation, oil prices are no longer significant after adjusting for unemployment rates and inflation. In this example, the total sales would be shark attacks (the thing that is being predicted), and oil prices would be ice-cream sales. Although the two seem to be related initially, it is not a true relationship – introducing other variables proves that they are not directly related. In this case, both unemployment and inflation rates would be like temperature. They are somehow related to oil prices behind the scenes. When controlling for them in the model, the price of oil loses its significance, and is no longer a direct predictor of Canadian automobile sales. However, this is not to say that oil prices are unimportant to the story of the declining market in the early 1980s. As stated in the introduction, the dramatic increase in the price of oil is what launched Canada into a recession. This recession gave rise to high inflation and high unemployment. So, even though oil is not directly correlated to auto sales after controlling for inflation and unemployment, it does affect other factors which are directly correlated to sales.

5.0 Discussion

5.1 Summary

This study started by looking at new vehicle sales in Canada. After some preliminary analysis, it was clear that sales dropped dramatically in the early 1980s. After doing some literature review, three variables of interest were selected as possible reasons why sales slumped during this time: oil prices, unemployment rate, and inflation rate. Each variable was inspected to discover trends, and it was found that all three variables were high when sales were low. Using multiple RDD models, it was clear that sales underwent a period of low sales in the early 1980s but started to rebound in 1983. Although it was clear that there was a drop in sales, the RDD models could not explain why these changes occurred. Linear models were then constructed to analyze correlation of the different variables with total vehicle sales. All three variables had significant correlation. The fact that oil prices were positively correlated with vehicle sales was unexpected, and it was hypothesized that the three independent variables were interacting in some way. To test this hypothesis, a multiple linear regression model was created. After controlling for unemployment and inflation rates, the positive correlation with oil prices became insignificant. Ultimately, this paper looked to inspect why Canadian automobile sales dropped in the early 1980s. Research showed that historically, oil prices led to a recession in the late 1970s, which caused unemployment rates and inflation to increase in Canada. These two factors were associated with low vehicle sales. Oil was not correlated but is likely the reason why the other two factors were so high.

5.2 Key Findings

In this paper, it was discovered that oil prices are not a good predictor of automobile sales in Canada. Even though oil prices more than doubled during the same period sales slumped, the two are not related. As shown in the linear regression, initial findings were that oil prices were positively correlated with vehicle sales – not negatively. This was an unexpected finding when comparing it to the rest of the research. Nonetheless, after controlling for the other two variables (unemployment and inflation), the oil price correlation became insignificant. Canadians may complain about prices at the pump, but they are still purchasing new vehicles.

Another discovery made in this paper was that unemployment and inflation rates were significantly correlated to vehicle sales and can be used to predict future sales. Both variables had negative associations. Intuitively, these results make sense. If people are not working, they are not likely to have the income to purchase a new vehicle. Additionally, if their dollar is worth $1.00 one year and $0.88 the next, it is unlikely they will be able to afford a new vehicle since their money is no longer worth what it once was.

An interesting hypothesis based on literature review is that oil prices indirectly affected other factors that are associated with automobile sales. Even though oil prices were not significantly correlated to automobile sales, it is possible that the skyrocketing price of oil launched a global recession, which led to an increase in unemployment and inflation rates in Canada. So, even though oil prices are not directly associated with a decrease in sales, it is possible that increased prices still had a hand to play in the story.

5.3 Causality

Even though this paper speaks to correlation, it is not able to speak to causality. RDD models are generated to show causality between two variables using a specific cut-off point. The cut-off point is associated with the independent variable. If there is a large decrease or increase in the dependent variable at the cut-off point, then it can be inferred that the change in the dependent variable is because of the cut-off point of the independent variable. For example, someone who gets a 90% average is not that different from someone who has an 89% average, but are students with a 90% average more likely to be accepted into universities? In this case, an RDD model could be created with grades on the x axis and university acceptance rates on the y axis. If acceptance rates saw a significant jump at 90%, then it could be reasoned that increased acceptance rates were due to someone receiving a 90% instead of an 89%.

In this study, though, time was used as the independent variable. Time itself cannot be used for causation. A year is not a reason for something to happen. Multiple things occur in any given year, and it is those variables that cause drops in dependent variables. In this study, RDD was used to inspect different years in the early 1980s that experienced drops in automobile sales. The other variables are what led to the drop in car sales, not the year. However, the other variables did not have a distinct cut-off point to examine, and thus, an RDD model could not be designed to inspect causality between oil prices, unemployment rates, inflation, and vehicle sales.

After conducting research into the socioeconomic factors of the 1970s and early 1980s, it is likely that the skyrocketing oil prices are what led to the Canadian recession, ultimately increasing unemployment rates and inflation. With no jobs and their money being worth less than it was in the past, Canadians were not in the market to purchase new vehicles. The multiple linear regression model supports this hypothesis, as oil prices lose significance after controlling for unemployment and inflation, and unemployment and inflation are significantly associated with automobile sales. Statistically, there is no evidence to show that the increased price of oil is what caused increased unemployment and inflation.

If this study could speak to causality, then it could be claimed that low automobile sales are caused by high unemployment and inflation rates. With causation, companies could use these two variables to predict their future sales and could alter production to better fit the projected sales. Additionally, the claim that oil prices are what caused the increase in unemployment and inflation would be confirmed.

5.4 Ethics

As with any statistical study, possible ethical concerns can arise. On a local scale, the dataset used for automobile sales only focused on the purchase of new vehicles. Lots of Canadians will never purchase a new vehicle in their lifetime. Those in lower socioeconomic classes were therefore not included in the study. People in this category (who live paycheck-to-paycheck) are likely more focused on the price of gasoline. For them, a doubling in the price of gas could be a reason for them to not purchase a vehicle. Those who can afford a new vehicle may be less likely to care so much about the price of oil, and not take it into consideration

when purchasing a vehicle. Therefore, the results of this study could be flawed, as they did not take an entire socioeconomic class into account.

On a larger scale, it seems bizarre to leave so much power in the hands of oil companies. They can launch a global recession if they decrease production and increase the price of oil. Additionally, as more people become dependent on automobiles for their everyday life, these oil companies can hike prices, as they know people will have to pay. If oil is indeed a necessity, then there should be rules and regulations stopping rapid increases in price.

5.5 Weaknesses

This study proved to have some interesting findings, but it did have its weaknesses. As mentioned above, it only focused on the sales of new automobiles, leaving out an entire socioeconomic class from the study. It used inflation rates from a website who cite Statistics Canada, but the data is not directly from the source. Additionally, the world oil price dataset was not directly from OPEC, but from a German company who monitored OPEC prices. It is unlikely, but possible, that these datasets were not accurate. Also, oil prices were reported as world oil prices, not Canadian oil prices, which could have led to different results. However, Canadian prices will always be related to the OPEC price, and the results would likely be similar. Finally, the study cannot speak to causality because time was selected as the independent variable in the RDD model and other variables did not have a distinct cut-off point.

5.6 Next Steps

For this time period in particular, the next step would be to determine if the doubling of oil prices is what caused the increase in unemployment and inflation rates. Based on historical evidence, this is likely. Nonetheless, having statistical evidence would increase the credibility of this claim. Although an RDD design would not be possible, other statistical methods could be used, such as a difference-in-difference model. After determining if oil caused the rise in unemployment and inflation, it should be determined if unemployment and inflation did, in fact, cause a decrease in automobile sales. For now, they are merely correlated variables. Next, it would be interesting to inspect what was happening in the 1990s, and just before 2010. Automobile sales also decreased during these times, and it would be interesting to see if the same factors were correlated with the decrease in sales (unemployment and inflation). Finally, it would be beneficial to be able to construct a model with causality to predict automobile sales. More variables are likely needed, although unemployment and inflation rates are a good start.

6.0 Conclusion

This paper inspected a specific time frame of Canadian automobile sales. Although the sector has seen general growth since its inception, there have been a few periods of drastic decreases in sales, such as the early 1980s. After doing some literature review, three variables of interest were determined: oil prices, unemployment rates, and inflation rates. Each variable was inspected at a surface level, and it was found that oil prices doubled in the late 1970s and both unemployment and inflation were high during the early 1980s. RDD models were designed to see the drop in sales in the early 1980s, showing that there was a significant change in automobile sales during this time. After, linear models were produced, with each factor being significantly correlated to auto sales individually. But, after running a multiple linear regression, it was determined that oil was merely taking credit for the affects of unemployment and inflation rates. It was found that after controlling for unemployment and inflation, oil prices were no longer correlated to auto sales. Although this paper cannot speak to causality from a statistical point of view, it is likely that the doubling of oil prices in the late 1970s triggered a recession in Canada, ultimately leading to high unemployment and inflation rates which are correlated to low automobile sales. In the future, models will be designed to

determine if oil is, in fact, what caused an increase in inflation and unemployment, and if unemployment and inflation are what caused the decrease in automobile sales. For now, it can only be stated that these factors are correlated to one another. Additionally, other time periods will be studied to further increase the strength of the model, with the goal of predicting future automobile sales using multiple variables. Unemployment rates and inflation are a good start, but other socioeconomic factors likely affect sales as well.

References

Auguie, Baptiste. 2017. *GridExtra: Miscellaneous Functions for "Grid" Graphics*. https://CRAN.R-project.org/package=gridExtra.

Canada, Bank of. n.d. *Inflation*. https://www.bankofcanada.ca/core-functions/monetary-policy/inflation/#:~:text=The%20Bank%20of%20Canada%20aims,consumer%20price%20index%20(CPI).

Canadian Vehicle Manufactuer's Association, CVMA. 2021. *Important Facts*. https://www.cvma.ca/industry/facts/.

Development, Economic, and EDT Trade. 2013. *New Motor Vehicle Sales*. Alberta, Canada: Government of Alberta. https://open.canada.ca/data/en/dataset/28caed1c-12cf-48ea-80b3-2a518cd58be8.

Downey, Lucas. 2020. *1979 Energy Crisis*. https://www.investopedia.com/terms/1/1979-energy-crisis.asp.

Firke, Sam. 2021. *Janitor: Simple Tools for Examining and Cleaning Dirty Data*. https://CRAN.R-project.org/package=janitor.

Francois, Romain. 2020. *Bibtex: Bibtex Parser*. https://CRAN.R-project.org/package=bibtex.

Government of Canada, GC. 2019. *Vehicles Made in Canada 2018*. https://www.ic.gc.ca/eic/site/auto-auto.nsf/eng/am00767.html.

History.com Editors, History Channel. 2010. *Energy Crisis (1970s)*. https://www.history.com/topics/1970s/energy-crisis.

Hugh-Jones, David. 2021. *Huxtable: Easily Create and Style Tables for Latex, Html and Other Formats*. https://CRAN.R-project.org/package=huxtable.

Inflation.eu. 2021. *Inflation Canada 1981*. https://www.inflation.eu/en/inflation-rates/canada/historic-inflation/cpi-inflation-canada-1981.aspx.

Inflation EU, InflationEU. 2021a. *Historic Inflation Canada - Cpi Inflation*. (https://www.inflation.eu/en/inflation-rates/canada/historic-inflation/cpi-inflation-canada.aspx).

———. 2021b. *Inflation.eu Information Sources*. https://www.inflation.eu/en/information-sources.aspx).

James, G., D. Witten, T. Hastie, and R. Ribshirani. 2017. *An Introduction to Statistical Learning with Applications in R*. Springer. https://static1.squarespace.com/static/5ff2adbe3fe4fe33db902812/t/6062a083acbfe82c7195b27d/1617076404560/ISLR%2BSeventh%2BPrinting.pdf.

Kose, Ayhan. M., N. Sugawara, and M. E. Terrones. 2020. "Global Recessions." Report Policy Research Working Paper 9172. World Bank Group.

Mansbridge, P., and M. Duffy. 1983. *Unemployment Reaches All-Time High in 1982*. https://www.cbc.ca/archives/entry/unemployment-reaches-all-time-high-in-1982.

Müller, Kirill. 2020. *Here: A Simpler Way to Find Your Files*. https://CRAN.R-project.org/package=here.

Organization of the Petroleum Exporting Countries, OPEC. 2021. *Average Annual Opec Crude Oil Price from 1960 to 2021*. Germany: Sönnichsen, N.; MWV. https://www.statista.com/statistics/262858/change-in-opec-crude-oil-prices-since-1960/.

Pipeline Technology Conference. 2021. *MWV - Association of the German Petroleum Industry*. https://www.pipeline-conference.com/companies/mwv-association-german-petroleum-industry#:~:text=Association%20was%20founded%20in%201946,preparation%20of%20laws%20and%20regulations.

R Core Team. 2020. *R: A Language and Environment for Statistical Computing*. Vienna, Austria: R Foundation for Statistical Computing. https://www.R-project.org/.

Ruppenthal, K. M., and Laura N. Bonikowsky. 2006. *Automobile*. https://www.thecanadianencyclopedia.ca/en/article/automobile.

Sawyers, Arlena. 2013. *1979 Oil Shock Meant Recession for U.s., Depression for Autos.* https://www.autonews.com/article/20131013/GLOBAL/310139997/1979-oil-shock-meant-recession-for-u-s-depression-for-autos.

Statistics Canada, StatsCan. 2021. *Archived - Unemployment Rate, Participation Rate, and Employment Rate by Sex, Annual, Inactive.* Canada: Government of Canada. https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=1410001802&cubeTimeFrame.startYear=1976&cubeTimeFrame.endYear=2018&referencePeriods=19760101%2C20180101.

StatsCan. 2021. *Vehicle Registrations, by Type of Vehicle.* https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=2310006701.

Wickham, Hadley. 2016. *Ggplot2: Elegant Graphics for Data Analysis.* Springer-Verlag New York. https://ggplot2.tidyverse.org.

Wickham, Hadley, Mara Averick, Jennifer Bryan, Winston Chang, Lucy D'Agostino McGowan, Romain François, Garrett Grolemund, et al. 2019. "Welcome to the tidyverse." *Journal of Open Source Software* 4 (43): 1686. https://doi.org/10.21105/joss.01686.

Xie, Yihui. 2021. *Tinytex: Helper Functions to Install and Maintain Tex Live, and Compile Latex Documents.* https://github.com/yihui/tinytex.