The Effects of Exchange Rate Fluctuations on Canada's Automotive Industry

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A. Introduction

The relationship between exchange rates and economic growth in general and specific industry GDP growth in particular has long been of interest to economists. Studies within this body of literature found that poorly managed exchange rates can be detrimental to economic growth (Rodrik, 2008), and that overvalued currency can lead to negative outcomes in economic growth (Easterly, 2005). Rodrik (2008, p. 3) extended this logic to undervaluation, concluding that the latter facilitates economic growth, especially in developing countries, by “increasing the relative profitability of their tradables.”

More recent research analyzed the causal mechanisms that support the positive association between depreciated exchange rates and economic growth. There are several theories that could explain this relationship. First, and most evident, a depreciated exchange rate can boost exports and promotes a shift to manufacturing resources, both of which support economic growth in the short and long run (Magud & Sosa, 2010 and Eichengreen, 2008). Second, and perhaps more compelling, studies show that depreciated exchange rates help accelerate economic growth by increasing domestic savings and capital accumulation, which eventually leads to higher levels of domestic investment as well as higher levels of employment in developing countries (Levi-Yeyati & Sturzenegger, 2007 and Gluzmann et al., 2012). Whatever the causal mechanism that ties exchange rates to economic growth may be, the relationship seems to remain robust across model specifications and different time series.

However, the above research program limits itself to developing countries when implying the connection between depreciated exchange rates and economic growth. Canada is an advanced economy dependent on exports including manufacturing. It maintains a strong manufacturing sector, especially in automobile manufacturing. Moreover, Canada is a resource-rich country exporting high volumes of oil and minerals, which places upward pressure on the currency. These factors make Canada an interesting case to study the effects of exchange rates on growth, in the context of resource abundance.

Resource-abundant countries have strained exchange rates that suffer from upward pressures due to the influx of foreign currencies. There is an equally large literature examining the relationship between exchange rates and “Dutch Disease”, which refers to currency appreciation as a result of the discovery of natural resources. Appreciation makes exports less competitive in international markets and harms manufacturing and, as a result, negatively impacts economic growth. Magud and Sosa (2010) found that natural resource booms are indeed associated with the appreciation of the real exchange rate and the subsequent decrease in manufacturing output.

The Canadian automotive industry output is situated at the intersection of all these interrelationships. It is affected by oil prices as Canada is one of the largest exporters of the commodity. The latest price crash of oil led to the depreciation of the Canadian currency. Therefore, the Canadian case is consistent with the Dutch Disease phenomenon.

This study revisits the relationship between exchange rates, natural resources, and output in the context of the automotive industry. More specifically, we ask whether the value of the Canadian currency against five main export partners has an effect on Canada's total motor vehicle GDP, motor vehicle parts GDP, and assembled motor vehicle GDP. If the literature on Dutch Disease and on the relationship between exchange rates and growth are correct, we would expect a lower Canadian dollar value to boost motor vehicle exports and lower oil prices to do the same. Our results are consistent with the cited literature and imply that the previous findings can be extended, at least in part, to developed countries with abundant resources.

B. Background

The automotive manufacturing industry has long been a crucial component in Canada's economy. The industry, which includes automotive parts and assembled vehicles, has represented between 7% and 11% of the annual total gross domestic product (GDP) of Canada's manufacturing sector since 1995 (Sweeney, 2013). At its peak in the late 1990s and early 2000s this figure amounted to nearly $20 billion and a significant contribution to Canada's overall GDP. While there has been some decline over the past decade, automotive manufacturing has maintained its position of importance in the Canadian economic landscape and is a defining characteristic of Canada as a global trade partner. Globally, Canada ranks 11th among all nations in motor vehicle assembly (CAPC, 2013). The automotive manufacturing industry employs more than 140,000 Canadians in motor vehicle and motor vehicle parts manufacturing, a figure which accounts for nearly 8% of all manufacturing jobs in Canada (Sweeney & Mordue, Forthcoming).

This study aims to investigate the causal link between Canada's automotive industry and fluctuations in the exchange rates of the Canadian dollar with the currencies of five key trading partners: the United States, Japan, the European Union, Mexico, and South Korea. These countries were chosen because of their importance to Canada as automotive trading partners. Combined they account for approximately 97% of Canada's total automotive trade (i.e. exports and imports) by value (Holmes, 2015). Tables 1 through 5 display the automotive trade balance for Canada and the US, EU, Mexico, Korea, and Japan, respectively.

The Canadian dollar spent much of the 2000s in a position of relative weakness when compared to its American counterpart (Figure 1). It was only after the U.S. economy declined as a result of the 2008 recession that any parity between the currencies was achieved. Following the Canadian dollar's peak in 2011 there has been a steady decline in its value and a reversion to pre-recession levels in the U.S. – Canada exchange rate.

Table 1: Motor Vehicle Manufacturing Exports, Imports, and Trade Balance between Canada and the U.S., 2000-2015 (billions of Canadian dollars)

Year	Total Exports	Total Imports	Trade Balance
2000	8.25	5.70	2.55
2001	7.83	5.32	2.50
2002	8.19	5.91	2.27
2003	7.40	5.42	1.98
2004	7.70	5.23	2.47
2005	7.34	5.01	2.32
2006	6.73	4.86	1.86
2007	6.49	4.97	1.52
2008	4.95	4.19	0.76
2009	3.57	3.14	0.44
2010	4.94	3.86	1.08
2011	5.07	3.89	1.18
2012	5.90	4.21	1.69
2013	5.84	4.43	1.41
2014	6.33	4.84	1.49
2015	7.26	5.41	1.85

Source: Strategis Trade Data, Industry Canada, 2016

Figure 1: U.S. Dollar - Canadian Dollar Exchange Rate, 2000-2015

Source: Bank of Canada

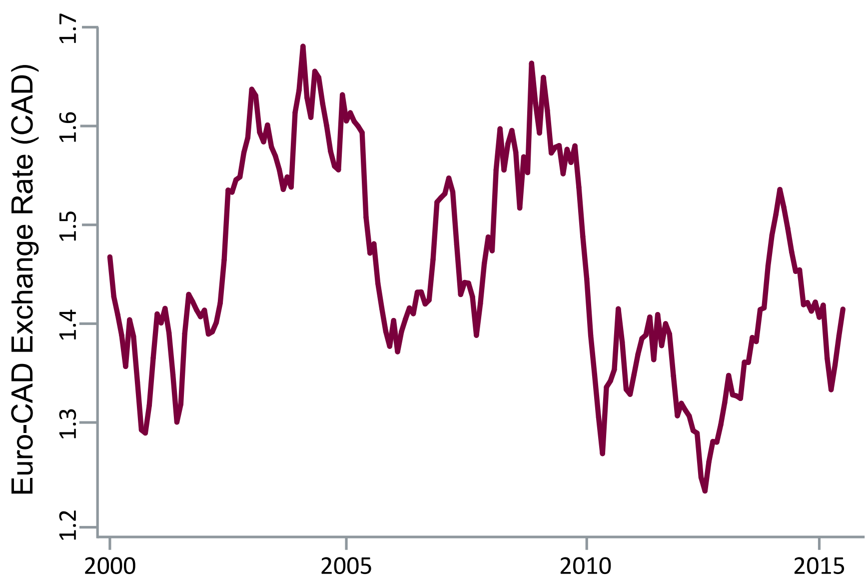
The euro has remained strong compared to the Canadian dollar over the sample period, trading at a value of more than 1.50 CAD during the mid-2000s and toward the end of the decade (Figure 2). Despite this fact there has been noticeable volatility in the exchange rate with alternating shifts between periods of relative strength and weakness for the Canadian dollar.

Table 2: Motor Vehicle Manufacturing Exports, Imports, and Trade Balance between Canada and the European Union, 2000-2015 (billions of Canadian dollars)

Year	Total Exports	Total Imports	Trade Balance
2000	0.04	0.26	-0.22
2001	0.03	0.26	-0.23
2002	0.03	0.32	-0.29
2003	0.04	0.34	-0.30
2004	0.05	0.39	-0.34
2005	0.05	0.38	-0.32
2006	0.05	0.42	-0.37
2007	0.05	0.40	-0.35
2008	0.03	0.45	-0.41
2009	0.02	0.37	-0.35
2010	0.02	0.44	-0.42
2011	0.02	0.47	-0.45
2012	0.03	0.55	-0.52
2013	0.03	0.55	-0.53
2014	0.03	0.61	-0.58
2015	0.03	0.71	-0.68

Source: Strategis Trade Data, Industry Canada, 2016

Figure 2: Euro – Canadian Dollar Exchange Rate, 2000-2015



Source: Bank of Canada

The exchange rate for the currencies of Mexico and Canada shows a clear trend since the turn of the new millennium (Figure 3). After reaching a peak of nearly 0.18 CAD in the early part of the last decade the peso has seen a consistent decline in relative value, stabilizing around 0.08 CAD in the 2010s.

Table 3: Motor Vehicle Manufacturing Exports, Imports, and Trade Balance between Canada and Mexico, 2000-2015 (billions of Canadian dollars)

Year	Total Exports	Total Imports	Trade Balance
2000	0.05	0.49	-0.44
2001	0.08	0.48	-0.40
2002	0.05	0.50	-0.45
2003	0.04	0.46	-0.43
2004	0.05	0.45	-0.40
2005	0.09	0.48	-0.39
2006	0.10	0.48	-0.38
2007	0.09	0.54	-0.44
2008	0.09	0.51	-0.42
2009	0.07	0.49	-0.42
2010	0.07	0.70	-0.62
2011	0.06	0.76	-0.70
2012	0.07	0.81	-0.73
2013	0.08	0.86	-0.78
2014	0.08	1.00	-0.91
2015	0.13	1.14	-1.01

Source: Strategis Trade Data, Industry Canada, 2016

Figure 3: Mexican Peso – Canadian Dollar Exchange Rate, 2000-2015

Source: Bank of Canada

The Korean won spent the majority of the 2000s fluctuating in the range of 0.0011 to 0.0013 CAD (Figure 4). During the global financial crisis in the latter half of the decade the won depreciated sharply and plateaued at a value just above 0.0008 CAD. The won began its recovery only recently but has nearly returned to its value from the beginning of the sample period as of 2015.

Table 4: Motor Vehicle Manufacturing Exports, Imports, and Trade Balance between Canada and Korea, 2000-2015 (billions of Canadian dollars)

Year	Total Exports	Total Imports	Trade Balance
2000	0.01	0.08	-0.07
2001	0.001	0.11	-0.10
2002	0.001	0.14	-0.14
2003	0.001	0.16	-0.16
2004	0.001	0.18	-0.18
2005	0.001	0.17	-0.17
2006	0.001	0.17	-0.17
2007	0.001	0.17	-0.17
2008	0.001	0.17	-0.17
2009	0.001	0.19	-0.19
2010	0.001	0.20	-0.20
2011	0.001	0.20	-0.20
2012	0.001	0.26	-0.26
2013	0.002	0.28	-0.28
2014	0.002	0.29	-0.29
2015	0.004	0.32	-0.32

Source: Strategis Trade Data, Industry Canada, 2016

Figure 4: Korean Won – Canadian Dollar Exchange Rate, 2000-2015

Source: Bank of Canada

The relationship between the Japanese yen and the dollar has, like the euro, been volatile. From 2000 to 2015 the yen moved between a value of nearly 0.008 CAD and one above 0.014 CAD (Figure 5). Beyond the currency fluctuations a depreciating trend is observable for most of the previous decade. The yen recovered rapidly before the turn of the decade after reaching its lowest point during the financial crisis, but was unable to sustain its strength. The value of the yen appears to have stabilized in the past two years.

Table 5: Motor Vehicle Manufacturing Exports, Imports, and Trade Balance between Canada and Japan, 2000-2015 (billions of Canadian dollars)

Year	Total Exports	Total Imports	Trade Balance
2000	0.02	0.52	-0.51
2001	0.01	0.51	-0.49
2002	0.02	0.63	-0.61
2003	0.01	0.54	-0.53
2004	0.007	0.49	-0.49
2005	0.01	0.55	-0.54
2006	0.004	0.63	-0.63
2007	0.005	0.63	-0.62
2008	0.003	0.61	-0.61
2009	0.003	0.52	-0.51
2010	0.004	0.58	-0.58
2011	0.004	0.50	-0.50
2012	0.004	0.61	-0.61
2013	0.003	0.55	-0.55
2014	0.003	0.45	-0.45
2015	0.003	0.52	-0.52

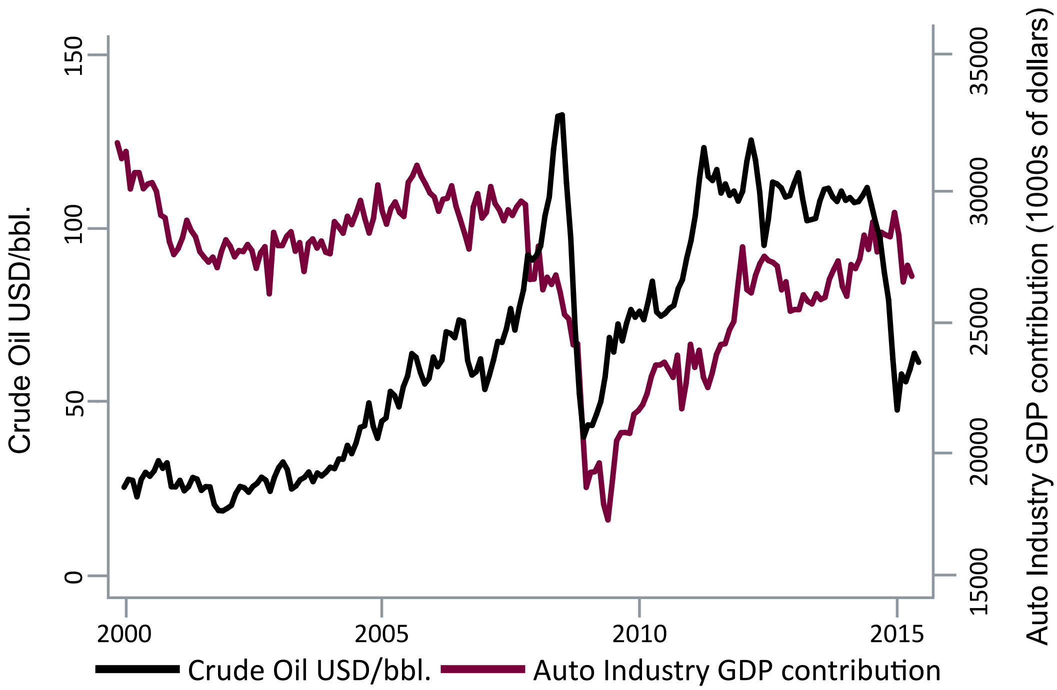
Source: Strategis Trade Data, Industry Canada, 2016

Figure 5: Japanese Yen – Canadian Dollar Exchange Rate, 2000-2015

Source: Bank of Canada

We also include the price of crude oil (in USD per barrel) as a way of accounting for the role of Canada's natural resources in the manufacturing sector and the potential for Dutch Disease. Some researchers have identified the negative impact a natural resource boom can have on a country's manufacturing sector (Magud & Sosa, 2010 and Frankel, 2012). Figure 6 presents the automotive manufacturing industry's contribution to Canada's GDP and the price of crude oil for the period 2000 to 2015. The upward trend in crude oil price peaks around the time of the global financial crisis in 2008 and coincides with a sharp decline in the GDP contribution of Canada's automotive industry. The Canadian dollar's value has been increasingly tied to crude oil prices (Stanford, 2011). Trends in the dollar's value and oil prices have shown overlap during the sample period, particularly during the recessionary years and as both have declined beginning in 2015. The inclusion of crude oil prices in our analysis will reveal the extent of their effect on the productivity of Canada's automotive manufacturing industry.

Figure 6: Price of Crude Oil and Automotive Industry Contribution to Total Canadian GDP, 2000-2015



Source: Statistics Canada, US Energy Information Administration

C. Methodology

The data used in this study were obtained from Statistics Canada, the Bank of Canada, and Macroeconomic Advisers. Monthly nominal exchange rate figures from 2000 to 2015 were collected from the Bank of Canada for: the Canadian dollar and the U.S. dollar; the Canadian dollar and the euro; the Canadian dollar and the Mexican peso; the Canadian dollar and the Japanese yen; and the Canadian dollar and the South Korean won. Seasonally-adjusted monthly GDP data from 2000 to 2015 for motor vehicle manufacturing (NAICS 3361) and motor vehicle parts manufacturing (NAICS 3363) in 2007 constant dollars were obtained from Statistics Canada's CANSIM database. Macroeconomic Advisers prepared a dataset of monthly U.S. total GDP from 2000 to 2015 by request. The

2000 to 2015 time period was chosen as it includes data from before and after the economic slowdown, which began in 2008 and affected Canada's automotive manufacturing industry. The sample period provides insight into the role of exchange rate fluctuations in the automotive industry slowdown. Data used to construct the trade balance tables for each automotive trading partner were collected from Industry Canada's Strategis Trade Database. All trade figures are reported as billions of current Canadian dollars. We follow the methodology established in Holmes (2015) by collecting data for three automotive industry codes: Automobile and Light-duty Motor Vehicle Manufacturing (NAICS 33611), Motor Vehicle Parts Manufacturing (NAICS 3363), and Motor Vehicle Plastic Parts Manufacturing (NAICS 326193). NAICS 33611 represents assembled motor vehicles while NAICS 3363 and NAICS 326193 are collectively referred to as motor vehicle parts.

A non-stationary time series is a series with trends or seasonality that affect the value of the series at different points. If non-stationary series are used in analysis it is critical to ensure the effects of trends or seasonality are limited since any correlations between the variables cannot be assumed to remain constant over time (OTexts, 2016). In cases involving non-stationary series it is sometimes beneficial to utilize elements of both regression and time series models to best capture any true causal effects. To accomplish this we first stationarized the independent and dependent variables by computing the differences between consecutive observations for each series – a technique known as differencing. Differencing can eliminate trends by discarding the level (i.e. magnitude) aspect of the series (Nau, n.d.). The dependent variables were also subject to a logarithmic transformation to stabilize the series' variances, thereby allowing the application of regression analysis.

Each independent variable was lagged to create three additional regressors. Lagging the independent variables allowed us to see what effect they have on the dependent variables (i.e. total motor vehicle GDP, assembled motor vehicle GDP, motor vehicle parts GDP) while taking into account the timelines of investment decision in the automotive manufacturing industry. Each independent variable was lagged by a period of 6 months, 12 months, and 24 months to generate the new regressors. The lag periods were chosen as an approximation for the short-term, medium-term, and long-term windows on which investment decisions can be made. For instance, the 12 month lag on the crude oil price variable in the regressions is included to observe the effects of crude oil prices from a year ago on total motor vehicle GDP and its components (i.e. assembled vehicles, parts) today, meaning it captures the market's reactions to the price during that year. Additionally, the exchange rate and crude oil price variables were constructed as rolling averages on a quarterly basis where each entry in the series was the average of the subset of the three monthly figures beginning one month later than the subset used to calculate the previous entry in the series. This method was used to limit the effect of outlier values in the original sample. After differencing and lagging the variables the analysis proceeded with a series of three ordinary least squares (OLS) regressions run in SPSS.

D. Results of Regression Analysis

Tables 6, 7, and 8 show the results of linear regressions for total motor vehicle GDP growth, assembled motor vehicle GDP growth, and motor vehicle parts GDP growth. Each table lists the set of independent variables, regression coefficients (i.e. the magnitude of the independent variable's causal effect on the dependent variable) in both unstandardized and standardized form, standard errors and t-statistics. The final column holds the p-values that determine which variables have a statistically significant causal effect. The significance threshold for these regressions is 0.10, meaning any variable with a value below the threshold is significant.

Table 6: Effect of Exchange Rate Fluctuations, Crude Oil Prices, and U.S. GDP on Total Motor Vehicle GDP Growth in Canada

	Unstandardized Coefficients		Standardized Coefficients		
Model	B	Std. Error	Beta	t	Sig.
(Constant)	-.001	.004		-.334	.739
lag6avgUSDCAN	.690	.606	.220	1.139	.257
lag12avgUSDCAN	.170	.660	.054	.258	.797
lag24avgUSDCAN	1.224	.666	.380	1.838	.068*
lag6avgJPYCAN	-28.662	27.768	-.181	-1.032	.304
lag12avgJPYCAN	-18.591	25.733	-.118	-.722	.471
lag24avgJPYCAN	56.155	22.940	.360	2.448	.016*
lag6avgEURCAN	.026	.223	.014	.118	.906
lag12avgEURCAN	.267	.230	.144	1.159	.248
lag24avgEURCAN	-.027	.188	-.015	-.144	.886
lag6avgMXNCAN	-3.724	3.278	-.157	-1.136	.258
lag12avgMXNCAN	2.441	3.059	.108	.798	.426
lag24avgMXNCAN	.939	3.055	.042	.308	.759
lag6avgKRWCAN	871.895	327.080	.338	2.666	.009*
lag12avgKRWCAN	-153.419	310.655	-.060	-.494	.622
lag24avgKRWCAN	26.087	260.152	.010	.100	.920
lag6avgCrudeOil	-.002	.001	-.249	-1.588	.115
lag12avgCrudeOil	.000	.002	.026	.143	.886
lag24avgCrudeOil	-6.984E-5	.001	-.008	-.052	.959
lag6logUSGDP	-.730	.739	-.100	-.987	.325
lag12logUSGDP	-.064	.714	-.009	-.090	.928
lag24logUSGDP	-.850	.762	-.117	-1.117	.266

NOTES: All models are estimated by ordinary least squares (OLS) regression. p<0.10 for all regressions with (*) indicating significance. The dependent variable is the monthly growth rate of Canadian total motor vehicle GDP.

Table 7: **Effect of Exchange Rate Fluctuations, Crude Oil Prices, and U.S. GDP on Assembled Motor Vehicle GDP Growth in Canada**

Model	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	t	Sig.
(Constant)	-.002	.009		-.278	.782
lag6avgUSDCAN	1.763	1.547	.222	1.140	.256
lag12avgUSDCAN	.046	1.684	.006	.027	.978
lag24avgUSDCAN	2.449	1.699	.301	1.441	.152
lag6avgJPYCAN	-14.788	70.890	-.037	-.209	.835
lag12avgJPYCAN	-26.353	65.693	-.066	-.401	.689
lag24avgJPYCAN	125.769	58.564	.319	2.148	.034*
lag6avgEURCAN	-.225	.570	-.047	-.394	.694
lag12avgEURCAN	.484	.587	.103	.824	.412
lag24avgEURCAN	.100	.480	.022	.209	.835
lag6avgMXNCAN	-4.610	8.370	-.077	-.551	.583
lag12avgMXNCAN	3.323	7.811	.058	.425	.671
lag24avgMXNCAN	1.838	7.798	.032	.236	.814
lag6avgKRWCAN	1721.583	835.006	.264	2.062	.041*
lag12avgKRWCAN	-282.063	793.074	-.043	-.356	.723
lag24avgKRWCAN	-151.047	664.146	-.024	-.227	.820
lag6avgCrudeOil	-.007	.004	-.304	-1.920	.057*
lag12avgCrudeOil	.001	.004	.038	.205	.838
lag24avgCrudeOil	.001	.003	.048	.315	.753
lag6logUSGDP	-1.152	1.888	-.062	-.610	.543
lag12logUSGDP	-.952	1.822	-.051	-.522	.602
lag24logUSGDP	-.587	1.944	-.032	-.302	.763

NOTES: All models are estimated by ordinary least squares (OLS) regression. p<0.10 for all regressions with (*) indicating significance. The dependent variable is the monthly growth rate of Canadian assembled motor vehicle GDP.

Table 8: Effect of Exchange Rate Fluctuations, Crude Oil Prices, and U.S. GDP on Motor Vehicle Parts GDP Growth in Canada

	Unstandardized Coefficients		Standardized Coefficients		
Model	B	Std. Error	Beta	t	Sig.
(Constant)	-5.398E-5	.004		-.013	.989
lag6avgUSDCAN	.371	.694	.102	.534	.594
lag12avgUSDCAN	.463	.756	.127	.613	.541
lag24avgUSDCAN	1.425	.763	.383	1.869	.064*
lag6avgJPYCAN	-32.974	31.816	-.180	-1.036	.302
lag12avgJPYCAN	-9.478	29.484	-.052	-.321	.748
lag24avgJPYCAN	64.979	26.284	.361	2.472	.015*
lag6avgEURCAN	.065	.256	.030	.252	.801
lag12avgEURCAN	.142	.264	.066	.540	.590
lag24avgEURCAN	-.016	.216	-.008	-.075	.941
lag6avgMXNCAN	-7.178	3.756	-.261	-1.911	.058*
lag12avgMXNCAN	3.362	3.505	.128	.959	.339
lag24avgMXNCAN	2.148	3.500	.083	.614	.541
lag6avgKRWCAN	1034.922	374.756	.347	2.762	.007*
lag12avgKRWCAN	115.729	355.937	.039	.325	.746
lag24avgKRWCAN	191.972	298.074	.067	.644	.521
lag6avgCrudeOil	-.002	.002	-.212	-1.364	.175
lag12avgCrudeOil	-.001	.002	-.081	-.447	.656
lag24avgCrudeOil	-.001	.002	-.058	-.386	.700
lag6logUSGDP	-.976	.847	-.115	-1.152	.251
lag12logUSGDP	-.365	.818	-.043	-.446	.656
lag24logUSGDP	-.865	.873	-.103	-.992	.323

NOTES: All models are estimated by ordinary least squares (OLS) regression. $p<0.10$ for all regressions with (*) indicating significance. The dependent variable is the monthly growth rate of Canadian motor vehicle parts GDP.

E. Discussion and Analysis

Table 6 displays results for the first regression, with the growth rate of total motor vehicle GDP as the dependent variable. The second regression uses one of the components of total motor vehicle GDP growth – the growth in GDP for assembled motor vehicles only – as its dependent variable (Table 7). The final regression has as its dependent variable the other major component of total motor vehicle GDP growth, the growth in motor vehicle parts GDP (Table 8). The explanatory variables include the exchange rates for the Canadian dollar with five other currencies: the U.S. dollar (USDCAN), the Japanese yen (JPYCAN), the euro (EURCAN), the Mexican peso (MXNCAN), and the Korean won

(KRWCAN). Each exchange rate is represented with three different regressors to capture any short (6 month), medium (12 month), and long-term (24 month) causal effects as a reflection of the different time horizons on which investment decisions are made. This is accomplished by applying lags of 6 months (lag6), 12 months (lag12), and 24 months (lag24) respectively. The explanatory variables also include a set of regressors with the same lags to capture the impact of the price of crude oil (in USD per barrel). The final explanatory variable is monthly U.S. total GDP growth which accounts for the dominant position that Canada's automotive trade with the U.S. holds with respect to other principal trading partners. Because trade between the two nations accounts for nearly 80% of Canada's automotive trade by value as of 2014 it is reasonable to assume that changes in U.S. economic growth would affect Canadian automotive manufacturing GDP (Holmes, 2015). As with the other explanatory variables, monthly U.S. GDP growth is lagged at 6 months, 12 months, and 24 months.

Our analysis revealed several independent variables that have a statistically significant effect on at least one of the dependent variables of interest. First, an appreciation in the U.S. dollar with respect to the Canadian dollar, as measured by the change in the quarterly moving average of the U.S.-Canada exchange rate, 24 months beforehand (lag24avgUSDCAN) was found to positively impact the growth of total motor vehicle GDP and motor vehicle parts GDP. The U.S. and Canada have remained each other's largest automotive trading partner despite the increasing globalization of manufacturing and the effects of the North American Free Trade Agreement (NAFTA), a trilateral pact signed between the two nations and Mexico, in the last two decades (Rutherford & Holmes, 2014). This is particularly true of automotive trade wherein Canada exports to the U.S., which has remained essentially unchanged as a percentage of Canada's total automotive exports by value over the sample period. In 1999 the U.S. was the destination for 98% of Canada's automotive exports while in 2014 it accounted for 96.9% (Holmes, 2015). In contrast, Canada's automotive imports from the U.S. declined noticeably over the same period, accounting for 82.1% of Canada's total automotive imports by value in 1999 but only 64.1% of imports by 2014. The U.S. is the only automotive trade partner studied with which Canada maintains a positive trade balance (Table 1; Holmes, 2015). This surplus has been driven entirely by the positive balance in assembled motor vehicle trade, as Canada has consistently run a negative trade balance in motor vehicle parts since signing the Automotive Products Trade Agreement (AutoPact), a precursor to NAFTA, with the U.S. in 1965 (Holmes, 2015). One explanation for the observed causal effect then is that the relatively stronger U.S. dollar encourages exports of Canadian automotive goods by increasing American demand.

Another significant regressor is the 6 month lagged change in the quarterly moving average of the Canadian dollar – Mexican peso exchange rate (lag6avgMXNCAN), which is observed to have a negative causal effect on growth in motor vehicle parts GDP. This implies motor vehicle parts GDP growth increases as the peso depreciates with respect to the Canadian dollar, though there are other factors which may cause this correlation. Canada's automotive trade relationship with Mexico has evolved more since 2000 than perhaps any other relationship examined in this report. Mexico has gone from accounting for only 2.7% of Canada's total automotive trade by value in 1999 to 7.7% by 2014 (Holmes, 2015). This sharp increase has been driven largely by growth in

Canadian automotive imports from Mexico, which increased from 5.5% to 13.2% of all Canadian automotive imports by value over the same period. Mexico now ranks as Canada's second largest source of automotive import though it still trails the U.S., which accounts for 64.1% of the country's imports as of 2014, by a large margin. Mexico has matured as a hub for North American automotive manufacturing and production since the introduction of NAFTA in 1994. This shift may be driven in part by Mexico's automotive industry labour costs, which are much lower than in both the U.S. and Canada (CAPC, 2013). Total labour costs at Ford, General Motors, and FCA in Mexico are between US$8 and US$10 hour. In contrast, hourly wages at Ford, General Motors, and FCA in the US and Canada range between US$40 and US$60 an hour (Sada, 2015). This wage gap represents a significant cost advantage for automakers who choose to locate operations in Mexico. Low labour costs also act to counter the benefits of shifting production to Canada in response to a relatively weak Canadian dollar, which may explain why no causal effect was noted for total motor vehicle GDP growth or assembled vehicle GDP growth. The causal effect that was observed implies that growth in motor vehicle parts GDP is positively impacted by a depreciating trend in the peso with respect to the Canadian dollar 6 months prior. This could be a result of the period before the global financial crisis of 2008 when Canada's trade deficit with respect to Mexican automotive parts grew while its deficit in Mexican assembled vehicles remained stable (Holmes, 2015). During this period the volume of automotive trade between the two nations was much lower, meaning anomalous events could have had an outsized impact. The effect could also be driven by statistical noise from other factors influencing motor vehicle parts GDP growth that were not included in the regression.

An appreciation in the Japanese yen with respect to the Canadian dollar and the same 24 month delay (lag24avgJPYCAN) also yields a positive causal effect on total motor vehicle GDP growth, assembled motor vehicle GDP growth, and motor vehicle parts GDP growth. Japanese automakers began production in Canada in 1965 and now maintain a strong automotive presence comprised of both vehicle assembly and parts manufacturing (JAMA, 2015). Japan accounts for 3.3% of Canada's total automotive trade by value as of 2014 making it Canada's fourth largest automotive trading partner (Holmes, 2015). Canada has run a negative automotive trade balance with Japan for the entire 2000-2015 period (Table 5). Growth in the negative balance has been driven primarily by assembled motor vehicle imports from Japan, which grew steadily in the years before the global financial crisis. Japanese automakers with North American production and manufacturing facilities may decide to expand their Canadian operations or import more Canadian vehicles as the Canada's dollar becomes relatively weaker, leading to an increase in the growth of total motor vehicle GDP and its components.

The Korean won - Canadian dollar exchange rate also shows a statistically significant impact on automotive GDP growth. In this case it is the appreciation of the won with respect to the Canadian dollar from 6 months beforehand (lag6avgKRWCAN) that shows a positive impact. Like the Japanese yen, the Korean exchange rate is significant in all three regressions. While Korea may not maintain the same level of automotive manufacturing presence in Canada that the U.S. or Japan have there is still a significant volume of trade between the two countries. Automotive trade between Canada and Korea accounted for 2.1% of

Canada's total automotive trade by value in 2014 (Holmes, 2015). Canada has been a net importer of Korean automotive goods since 2000, running a negative trade balance as shown in Table 4. Partitioning automotive goods into assembled motor vehicles and motor vehicle parts reveals that the former is the main driver for the negative trade balance. The 6 month lag for the significant Korean won regressor is shorter than the 24 months observed for the American and Japanese exchange rate variables. The short lag is likely due to total motor vehicle GDP including both assembled vehicle and motor vehicle parts components, the latter of which can see its investment decisions influenced on a shorter horizon because of the interchangeable nature of parts. As the won appreciates Korean automakers use fewer Korean automotive parts and instead shift to Canadian automotive parts manufacturers, thereby boosting total motor vehicle GDP growth.

The final significant variable is the 6 month lagged quarterly moving average in the price (in USD per barrel) of crude oil (lag6avgCrudeOil), which is observed to have a negative causal effect on assembled motor vehicle GDP growth. This inverse relationship means a drop in the price of crude oil 6 months beforehand would increase the growth rate of assembled motor vehicle GDP today. The shorter 6 month lag fits with expectation since consumer behavior is more reactive than large-scale investment decisions. This theory also explains the lack of observed causal effect of crude oil price on motor vehicle parts GDP growth. Though parts are needed in the production of new vehicles, the ebbs and flows in consumer automotive spending as a reaction to gas prices is likely to be reflected only in cars that are ready for purchase. Moreover, short-lived trends in crude oil and gas prices lack the staying power to influence the vehicle production chain at the parts level.

The exchange rate variable that does not show a correlation with growth in total motor vehicle GDP, assembled motor vehicle GDP or motor vehicle parts GDP also aligns with expected results. The Canadian dollar – euro exchange rate was not observed to have any statistically significant causal effect on the dependent variables in any of its different lag iterations. While the volume of trade between Canada and the E.U. (4.5% of total automotive trade by value) is in the range of trade volumes for Canada with Japan (3.3%) and Korea (2.1%) it is spread amongst all E.U. member nations. Since currency fluctuations are only one determinant of the unique trade relationship Canada holds with each of its trading partners, summing together several countries may result in the negation of opposing causal effects and thus no observed significance. This could occur if a change in the exchange rate causes an increase in Canadian motor vehicle GDP growth through one E.U. member such as Greece, with which Canada has a positive automotive manufacturing trade balance, while simultaneously having the inverse effect on motor vehicle GDP growth through another E.U. member like Germany, which is a net automotive exporter to Canada.

Additionally, we did not observe a causal effect for monthly U.S. GDP growth rate in any of the regressions. Unlike the Canada – E.U. exchange rate this result is counterintuitive. Given that the bulk of Canada's automotive trade is done with the U.S. we would expect changes in the condition of the American economy to have a ripple effect in the productivity of Canada's automotive manufacturing industry. It is possible we would observe this impact if the sample period were extended to include years before 2000. The lack of causal effect could be due in part to re-shoring, as U.S. automakers have pushed to move their manufacturing operations from Canada back to the U.S. since the global financial crisis (CAPC, 2013). It may also simply be a byproduct of statistical noise caused by other factors which influence Canada's automotive industry but were not included in the regressions. In any case this is a surprising result that warrants further investigation.

Other Factors

While the results indicate a correlation between exchange rates and GDP growth for Canada's automotive manufacturing industry that aligns with the prevailing notions found in literature this analysis would not be complete without a brief overview of other factors that may impact the causal link of interest. A 2013 report by the Canadian Automotive Partnership Council (CAPC) includes a discussion of several factors that lead to both opportunities and challenges for Canada's automotive industry, some of which are summarized below:

Taxation

Canada's corporate tax system positions the country as a leader in offering automakers favourable rates, especially when compared to its NAFTA counterparts. Canada's corporate tax rate of 26% in 2013 bested Mexico's by 4% and the U.S. by 14%. The tax rate could thus be a predictor of automotive industry growth. One issue to note, however, is that many U.S. firms are unable to capture the full benefit of lower taxes because the income they earn in Canada is taxed in the U.S., with any Canadian taxes paid credited against U.S. taxes owing. Furthermore, restructuring following the automotive industry bailouts have left many companies unable to take advantage of low taxes for the foreseeable future.

Productivity

Improvements in automotive industry productivity are a crucial component of sustaining growth. Automakers typically make improvements in productivity and innovation on four to six year cycles either through construction of new facilities or upgrades to existing ones. We would expect these improvements to have a positive effect on GDP growth for the automotive sector. For Canada, productivity improvements are particularly important as a way of remaining competitive against the low labour costs offered by Mexico.

Tariffs and Trade

Canada's automotive manufacturing tariff regime is, much like its corporate tax system, a boon for automotive manufacturers, with no tariffs on motor vehicle parts destined for assembly plants. Moreover, Canada has pursued a series of bilateral and multilateral trade agreements that will have a major impact on the automotive sector. These agreements have the potential to open new avenues for automotive trade that boost industry growth via exports or hurt Canadian production by increasing outside competition in the market. This uncertainty acts as a reminder of the influence the political climate can have on investment decisions.

Utilities and Transportation

Costs are always a determinant of any automakers' investment decision and thus play a role in shaping growth for the automotive industry. Utilities and transportation are two of the largest costs faced by manufacturers. Utilities are an outside factor that automakers cannot determine but can still be advantageous, as seen with the low oil prices in Canada and declining cost of natural gas in the U.S. Transportation costs can influence where automakers build production facilities in relation to the market for their vehicles. This effect can be seen in the transportation costs incurred by companies with plants in Mexico, which are typically higher than those in Canada and the U.S. because of Mexico's distance to the primary motor vehicle markets in North America.

Automotive Ecosystem

Another factor that relates to transportation is the increasing integration of the automotive manufacturing industries of Canada and the U.S., particularly in the Great Lakes region spanning the border. Referred to as North America's economic engine, the Great Lakes region is home to more than 50% of U.S. automotive suppliers and 90% of Canadian automotive suppliers (Kavcic, 2013). With parts moving back and forth across the border during the production and assembly process it can be difficult to ascertain how fluctuations in the U.S – Canada exchange rate truly impact growth in Canada's automotive industry. To wit, a weaker Canadian dollar would decrease Canadian labour costs, an attractive feature for manufacturers, while also increasing costs for inputs from facilities located on the American side of the border.

Investment Decision Timetable

The causal link could also be muddled by the foresight and lead times involved in the investment decision-making timetables used by automotive manufacturers. Currency fluctuations are often built into automakers' investment decisions, with volatility above a certain threshold potentially having a chilling effect. Alternately, the short-term nature of currency fluctuations may result in their being unaccounted for entirely in the types of decisions made years prior, such as the construction of new facilities. In either case observations of the causal effect of interest could be affected.

This short list should be a reminder that the forces driving Canada's automotive manufacturing industry rely on a complex interplay that can make it difficult to analyze a single factor in isolation. For these reasons and a host of others we recommend further research into this topic.

F. Conclusion & Further Research

On aggregate, the causal effects observed in the regressions support the findings from literature regarding the relationship between exchange rates, natural resources, and output for the automotive manufacturing sector. A statistically significant correlation was found between Canada's total motor vehicle GDP and the exchange rates between the Canadian dollar with the currencies of four of Canada's five largest automotive trading partners: the United States, Japan, Mexico and South Korea. The regression results generally indicate that a relatively weaker Canadian dollar has a positive impact on total motor vehicle GDP and/or its components (i.e. assembled motor vehicle GDP and motor vehicle parts GDP), with the Canada-Mexico exchange rate as the lone exception. A causal effect was also observed for crude oil prices, reflecting the intuitive connection between Canada's commodity sector and the automotive manufacturing industry. In contrast, no causal effect was observed for the Canada-E.U. exchange rate or the monthly U.S. total GDP growth rate, both of which would benefit from further study.

There are a number of options for additional research stemming from the results of this study. The first avenue for extending this research is through the time series data, particularly the exchange rate series. Analyzing a longer sample period would provide more opportunities for trends to emerge and allow for the use of yearly rather than monthly data. Doing so would also eliminate the need to aggregate monthly data using a quarterly moving average. More independent variables could be added in order to limit the interference of statistical noise and increase the explanatory power of the regressions. One potential addition is Canada's total GDP growth rate. Since many facets of the country's economy are interconnected changes in overall productivity should impact the automotive manufacturing industry as well. The lag periods used to account for the different time horizons involved in automakers' investment decisions are another aspect of the study that warrants closer inspection. The lags were chosen based on conventional measures of short, medium, and long-term; it would be informative to research how such decision-making timelines are altered for automakers specifically.

There are also many opportunities to explore topics related to the main focus of this study. It would be useful to examine the effect of motor vehicle manufacturing trade balances (i.e. the difference in monetary value between automotive exports and imports) between Canada and the same group of automotive trading partners on the productivity of Canada's automotive manufacturing industry. Including trade balances would enhance the analysis by providing insight into the nature of Canada's key automotive trade relationships. Another possible extension is to determine the impacts of the same exchange rates that were the focus of this study on Canadian exports and imports from the main automotive trading partners, turning trade balances into the dependent variables. By doing so we could learn more about another potential channel through which currency fluctuations can effect Canada's automotive industry. Finally, these results can be used as an input in building a projection of Canada's automotive industry going forward and examining the potential effects of international trade agreements. Trade agreements could be included in the regressions as a set of indicator variables. Each trading partner would require a separate indicator variable which would take on a value of 0 or 1 depending on whether Canada has some form of trade agreement in place with that country or region.

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