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Master´s Programme in Economic Growth, Population, and Development

The Effects of Economic Growth, Energy Consumption, Trade, Urbanization, and Financial development on CO_2 Emissions in Canada

by

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Abstract

A noteworthy cause of climate change is the amount of CO_2 emissions released into the atmosphere. This study´s objective, therefore, is to examine the relationship between CO_2 emissions, economic growth, energy consumption, urbanization, trade and financial development in the case of Canada, one of the largest CO_2 emitters both in per capita and in absolute terms, over the period 1960-2014. For this purpose, this study applies both an ADF- and ZA-unit root test, an ARDL bounds testing approach to cointegration, a Granger causality test based on a VECM and lastly an innovative accounting approach. The results confirm that the variables are cointegrated and that GDP, GDP^2, energy consumption, and trade expands CO_2 emissions, in the long-run, whereas financial development and urbanization remain insignificant. The evidence, therefore, does not support the environmental Kuznets curve hypothesis since both GDP and GDP^2 positively relates to CO_2 levels. The causal analysis confirms that in the long-run, bidirectional causality is present between CO_2 emissions and energy consumption, CO_2 emissions and economic growth, as well as between economic growth and energy consumption. Moreover, the study confirms that urbanization, trade, and financial development all have bidirectional causal links with CO_2 emissions. Therefore, to expect economic growth to solve environmental issues, as suggested by the environmental Kuznets curve, is in the case of Canada not correct. Instead, there is an urgency for financial support, targeted policies, and advanced technologies to develop the Canadian economy and its energy sector sustainably.

Keywords: Canada; Environmental Kuznets Curve; CO_2 Emissions; Autoregressive Distributed Lag Method; Vector Error Correction Model

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List of Abbreviations

ADF	Augmented Dickey-Fuller Unit Root Test
AIC	Akaike information criteria
ARDL	Autoregressive Distributed Lag Method
CO_2	Carbon Dioxide
CUSUM	Cumulative Sum of the Recursive Residuals
CUSUMSQ	Cumulative Sum of Squared Recursive Residuals
ECM	Error Correction Model
ECT	Error Correction Term
EKC	Environmental Kuznets Curve
GDP	Gross Domestic Product
GHG	Greenhouse Gases
IAA	Innovative Accounting Approach
IPCC	Intergovernmental Panel on Climate Change
RESET	Ramsey Regression Specification Error Test
SBC	Schwarz Bayesian criterion
VECM	Vector Error Correction Model
ZA	Zivot-Andrews Structural Break Unit Root Test
VAR	Vector Autoregression

Variables

CO_2	Carbon Dioxide	**EC**	Energy Consumption
GDP	Gross Domestic Product	**GDP^2**	Gross Domestic Product Squared
FD	Financial Development	**TR**	Trade Openness
URB	Urbanization		

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1 Introduction

A significant threat facing us is global climate change. A noteworthy cause of climate change as stressed by the Intergovernmental Panel on Climate Change (IPCC) (2018), is the amount of greenhouse gas (GHG) released into the atmosphere. Out of the total amount of GHG produced, carbon dioxide (CO_2) emissions constitute the majority. Since the Industrial Revolution and the 1970s, global CO_2 emissions have accelerated such that it is now more than twofold compared to then (World Bank, 2007), and only from the 2000s the global CO_2 level have grown ten times the pace of any sustained upturn over the past 800,000 years (Lüthi, Le Floch, Bereiter, Blunier, Bernola, Siegenthaler, Raynaud, Jouzel, Fischer, Kawamura & Stocker, 2008; Bereiter, Eggleston, Schmitt, Nehrbass-Ahles, Stocker, Fischer, Kipfstuhl & Chappellaz, 2015).

The impact that CO_2 emissions pose on the environment has steered researchers´ interest towards its determinants. In particular, three main strands of literature have arisen. Firstly, the environmental Kuznets curve (EKC) hypothesis propose that an inverted-U-curve can characterize the relationship between economic growth and environmental pollution. Hence emissions increase up to a certain level of income and thereafter falls as income continues to rise (Grossman & Kruger, 1995; Galeotti & Lanza, 2005; Bilgili, Kockak & Bulut, 2016; Apergis, 2016). The second strand of literature investigates the link between energy consumption and economic growth. There is a possibility that the variables may be jointly determined, reducing energy use to decrease emission might, therefore, not be as straightforward (Kraft & Kraft, 1978; Stern, 1993, 2000; Lee, 2006, Dogan, 2014; Komal & Abbas, 2015).

More recently, Ang (2007) placed the energy – output- and the environment – output-nexus under one multivariate framework. This literature strand was later extended by controlling for additional variables, thus reducing omitted-variable bias. Therefore, are variables such as trade (Ang, 2009; Halicioglu, 2009; Jalil and Mahmud, 2009) and urbanization (Hossain, 2011; Sharma, 2011; Farhani, Shahbaz & Arouri, 2013) incorporated into the environmental function. More contemporary studies also identify and account for financial development. In an environment with a well-functioning financial system, technological advancements in the energy mix can adversely impact emissions (Kumaboğlu, Karali & Arikan, 2008).

However, few studies simultaneously account for energy consumption, real gross domestic product (GDP), trade, urbanization, and financial development in the environmental function. Authors such as Al-Mulali, Tang and Ozturk (2015), Farhani and Ozturk (2015), Dogan and Turkekul (2016) and Saidi and Mbarek (2017) among few others, tries to achieve unbiased estimates by doing this. Only these studies, to the authors best knowledge, accounts for the potential impact of urbanization, trade and financial development simultaneously, and similarly, only a small amount of research accounts for the effect of one or two of the control variables mentioned above while examining energy use and output on environmental health.

Due to the limited amount of studies and empirical results of financial development on environmental degradation, this study´s main contribution is that it aims to investigate the relationship among CO_2 emissions, total energy consumption, real GDP, real GDP^2, trade, urbanization, and financial development in Canada applying an econometric model deriving from the EKC hypothesis for the period 1960-2014. More precisely, this study contributes to the existing literature since, up until this moment, no previous author has stressed the importance of controlling for all these variables simultaneously when studying Canada. Therefore, this study attempts to answer the following question: *Does the environmental Kuznets curve theory describe the relationship between GDP and CO_2 emissions when controlling for the impacts of total energy consumption, urbanization, trade, and financial development?*

Since time series studies produce valuable policy implications, this study will focus on a single-country, Canada, instead of employing a panel study. While Canada has signed the Paris Agreement to fight climate change, recent reports suggest that contemporary policies are inconsistent with keeping global warming below 2 degrees and let alone with the stronger 1.5 degrees as stated in the Paris Agreement (Climate Action Tracker, 2018). Moreover, Canada receives a low score on an overall decarbonization performance rating in a recent report by Climate Transparency (2018). It also remains one of the largest emitters in terms of GHGs both in absolute terms and per capita. Similarly, the primary energy consumption per capita remains above the world average (Hughes, 2018).

To answer the research question proposed, this study collects data from the World Bank Development Indicators for the period 1960-2014 for both the dependent variable and the regressors. Furthermore, this study applies two different unit root test, an autoregressive distributed lag method (ARDL) to determine cointegration and to estimate short-run as well as long-run coefficients. Moreover, this study utilizes a vector error correction model (VECM) to determine causality and to determine the robustness of the causal analysis, this study employs an innovative accounting approach (IAA).

The empirical results confirm that none of the variables analyzed exceeds an integration order of one and that the variables are cointegrated. Moreover, in the long-run GDP, GDP^2, energy consumption, and trade expand CO_2 emissions, whereas financial development and urbanization remain insignificant. The evidence, therefore, does not support the environmental Kuznets curve hypothesis since both GDP and GDP^2 positively relates to CO_2 levels. The causal analysis confirms that in the long-run, bidirectional causality is present between CO_2 emissions and energy consumption, CO_2 emissions and economic growth, as well as between economic growth and energy consumption. Moreover, the study confirms that urbanization, trade, and financial development all have a bidirectional causal link with CO_2 emissions. These findings may provide new avenues for policy-making authorities to evolve comprehensive economic, financial, trade, and energy policy reforms to sustain economic growth.

The remainder of this study is as follows: Section 2 – *Background*, provides a short introduction to the Anthropocene and information on the Canadian energy system and the CO_2 emissions. Section 3 – *Related Literature*, provides an overview of the EKC theory and previous literature. Section 4 – *Empirical Framework*, summarizes the data collection process, describes the econometric model and the methodology used. Section 5 – *Results and Analysis,* reports findings from empirical testing, analyzes and draws policy implications. Section 6 – *Conclusion,* summarizes relevant points, draws conclusions, and makes suggestions for future research.

2 Background

2.1 A New Geological Epoch

Every year the IPCC issues a report regarding the future of the planet, often painting a rather bleak picture. There is plenty of evidence regarding the remarkable pace, and global scale human beings have had on the globe (Steffen, Leinfelder, Zalasiewicz, Waters, Williams, Summerhayes, Barnosky, Cearreta, Crutzen, Edgeworth, Ellis, Fairchild, Galuszka, Grinevald, Haywood, Ivar do Sul, Jeandel, McNeill, Odada, Oreskes, Revkin, Richter, Syvitski, Vidas, Wagreich, Wing, Wolfe & Schellnhuber, 2016). More precisely, human beings are a critical factor behind the increased global temperatures by producing GHG and conducting deforestation (IPCC, 2018). Therefore, scientists, for instance, Crutzen (2002), call for a recognition that the Earth has progressed into a new geological epoch, the so-called Anthropocene.

The noticeable environmental changes have raised our awareness and forced us to act drastically to alter our current behavior to save the planet (Apergis, Payne, Menyah & Wolde-Rufael, 2010). As a response to the environmental changes taking place, multinational organizations, one example being the United Nations, have attempted to abate the adverse effects of global warming through intergovernmental and binding agreements. One such arrangement is the Paris agreement a treaty that went into force 2016 with a primary ambition to reduce GHG emissions and to preserve the global temperature below 2 degrees (United Nations, 2015). Although world-wide actions are taken to counteract global warming, the level of CO_2 emissions in the atmosphere remains heightened, here Canada plays a vital role in being one of the more significant emitters.

2.2 The Canadian Energy System

What the environment demands is a rapid energy-system transformation. One can observe energy transitions throughout history with the Industrial Revolutions that have occurred. Consulting the past may, therefore, bring about useful insights about possible futures. Figure 2.1 illustrates the Canadian primary energy consumption by its source for the period 1965 to 2016. Most noticeably is the overall expansion of energy consumed, a trend that seems to continue upwards. Since 1965 Canada has more than tripled its total energy consumption, which according to Hughes (2018) implies that Canadian per capita energy consumption is five times the world average, 29% greater than the US, and almost three times larger than that of European Union in 2016. The Canadian inhabitants, therefore, utilize more energy than citizens in most other countries. The immense energy consumption may impose not only difficulties but also costs on an energy transition. In short, some of these challenges and costs derive from making improvements in energy efficiency, reshaping societies, sectors, value chains, and behaviors (Energy Transitions Commission, 2016; Netherlands Energy Research Alliance, 2019).

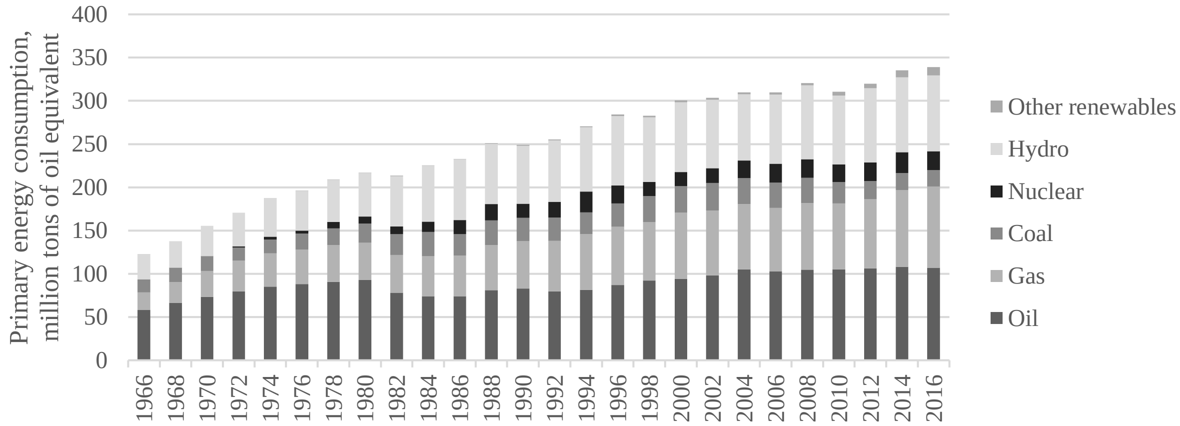

Figure 2.1 Canadian Primary Energy Consumption by Source, 1965-2016. (Source: BP, 2018)

The total fossil fuel consumption, on the other hand, seems to fall. Coal, oil, and natural gas are throughout the period depicted, providing less energy to the Canadian economy, especially the consumption of coal is weakening. However, the declining trend does not develop at a fast-enough pace. One can also note how the gas consumption increases, while having a lower carbon content, it is still not a clean energy source. Therefore, the Canadian total fossil fuel consumption still accounts for approximately 63% of the primary energy consumption in 2016. The Canadian share of fossil fuels is undoubtedly superior in comparison to the 85% contribution of fossil fuels to the global primary energy in 2016, and to countries such as China and Australia with 87% and 93% respectively. However, it is inferior in comparison to economies relying on low-emissions energy sources such as Sweden, with 35% in 2016 and Norway with 31% (BP, 2018).

Furthermore, Figure 2.1 demonstrates a considerable share of low-emission energy sources, especially hydropower, makes up a large share of the energy mix. According to Hughes (2018), Canada is among the five largest hydropower producers in the world. Also, nuclear power has surged in importance from the mid-1970s and onwards. Therefore, have low-emissions energy sources, here including nuclear-, hydro-, wind- and solar-power, from the 1980s until now accounted for almost a third of the primary energy consumption. However, strikingly is the slow extension of new low-emissions energy sources. Canada has particularly abundant reserves of both high-quality and cost-competitive wind (Canadian Wind Energy Association, 2019). Renewable energy sources, excluding hydropower, accounts for merely 3% of the Canadian total primary energy consumption in 2016 and is therefore barely visible in Figure 2.1. Therefore, Canada´s share of non-hydro renewables falls short to both the global value of 4% in 2016, as well as the European 10% in 2017 (BP, 2018, 2019). These facts suggest that actions taken in the case of Canada so far towards an energy transition fall short of the scale and rate needed.

Different energy systems have different connections to emissions. Low-emissions energy sources have a lower carbon content than fossil fuels. However, various fossil fuels also have different carbon contents, in which coal has the highest, followed by oil and natural gas (Baumert, Herzog, and Pershing, 2005). The fuel mix is, of course, highly correlated with a nation´s natural endowments. To further investigate the Canadian fuel mix, one can divide CO_2 emissions per capita with energy consumption per capita, seen in Figure 2.2 for the period 1960-2014. Seen is a rather stable curve up until the 1970s after that the curve trends downwards. Implying that after the 1970s, the economy adopts less carbon-intensive energy sources, hence decarbonizing the fuel mix, which is in line with Figure 2.1. Richard and He (2010) states that significant alternations took place as a response to the oil shock in the 1970s; one can interpret these changes as shifts against less polluting technologies. The link between CO_2 emissions and energy consumption continues to weaken with an average annual decline of 0.50% for the period plotted.

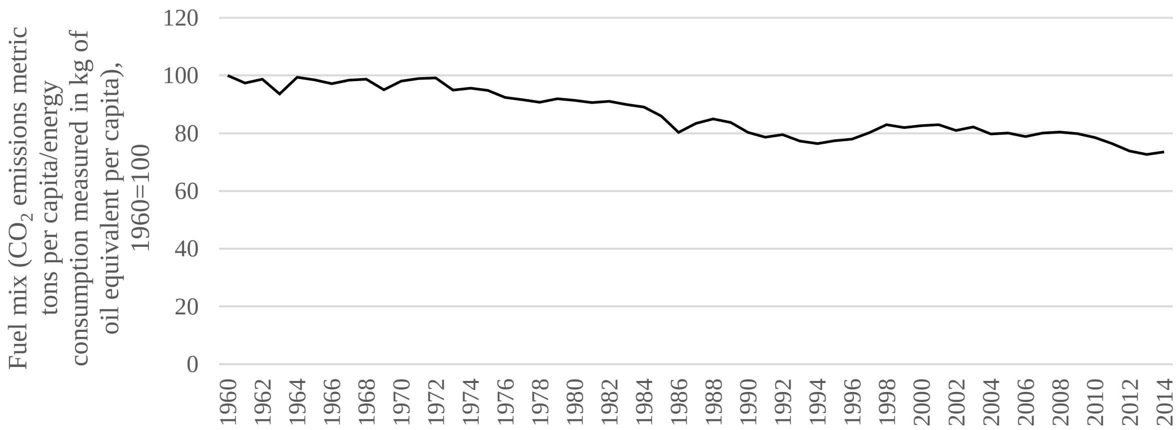

Figure 2.2 Canadian Fuel Mix, 1960-2014.

(Source: The World Bank, 2019a, 2019b)

Authors own calculations

Another measure is energy intensity, the amount of energy consumed per unit of GDP. As stated by Baumert, Herzog, and Pershing (2005) the measure, portrays not only the country´s level of energy efficiency but also the overall economic structure. The ambition is to decrease the amount of energy necessary to provide goods and services. Figure 2.3 reports the Canadian energy intensity for the period 1960-2014. In contrast to the fuel mix, the energy intensity portrays an increase up until the 1970s, and after that, falls. It, moreover, has a higher average annual decline for the period plotted, falling on average by approximately 0.77% annually. Similarly, to the fuel mix, there seem to be a decoupling of energy consumption and economic growth.

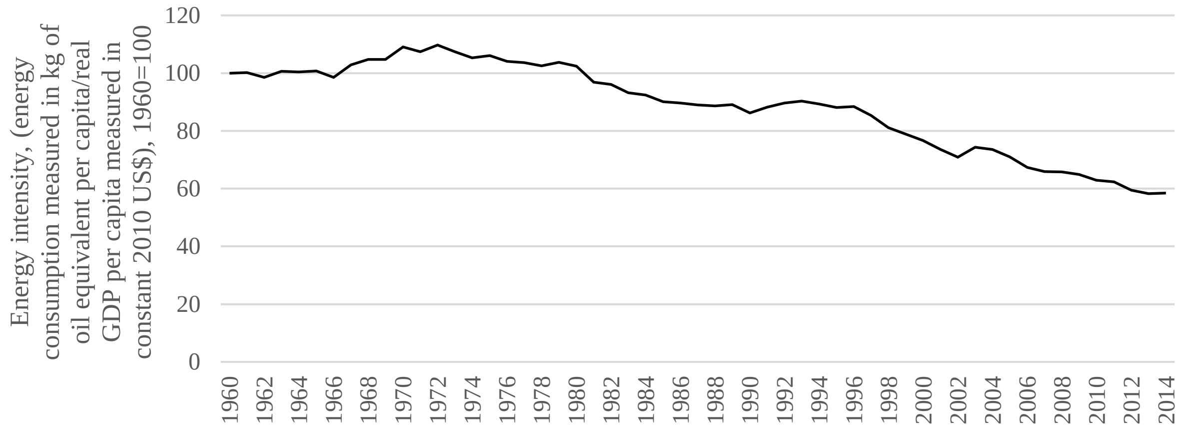

Figure 2.3 Canadian Energy Intensity, 1960-2014.

(Source: The World Bank, 2019b, 2019c)

Authors own calculations

2.3 The Canadian CO_2 Emissions

Similarly, to other developed economies, Canada´s emission profile is dominated by CO_2 (Environment and Climate Change Canada, 2018). Since fossil fuels remain predominant in the fuel mix, Canada´s per capita CO_2 emissions continue to lay above the world average, more precisely three times the global average, measured in per capita. Therefore, Canada emits more than twice that of China, and eight times the per capita emissions in India (BP, 2018).

In Canada, nearly all the energy-related CO_2 emissions derive from two sources, electricity and transports (Climate Transparency, 2018). According to Natural Resources Canada (2018), 81% of the emissions derive from energy. However, the dispersed population, the vast landscapes, and the extreme temperatures may explain why Canadians consume larger shares of energy. It is, therefore, essential to monitor energy use to gain an understanding of the impact it may have on the climate, especially since the significant contributions to GHG comes from the combustion of fossil fuels. These findings demonstrate that Canada´s fundamental challenge is to continue to delink economic growth from energy use.

To understand the trajectory of the Canadian CO_2 emissions, CO_2 emission in absolute terms, and its percentage growth rate is reported for the period 1960-2014 in Figure 2.4 and Figure 2.5. Observed is how the growth rate of the CO_2 emissions increases immensely up until the 1970s. While slowing down at the beginning of the 1970s, CO_2 emissions in absolute terms remain elevated at a higher level than previously observed and have yet not reverted to previous levels. So, while CO_2 emissions are not growing at the same pace as before the 1970s, they are indeed still expanding. Furthermore, in contrast to many European economies that have managed to reduce emissions from the 1990s and onwards, Canada has instead increased its levels (The Conference Board of Canada, 2019).

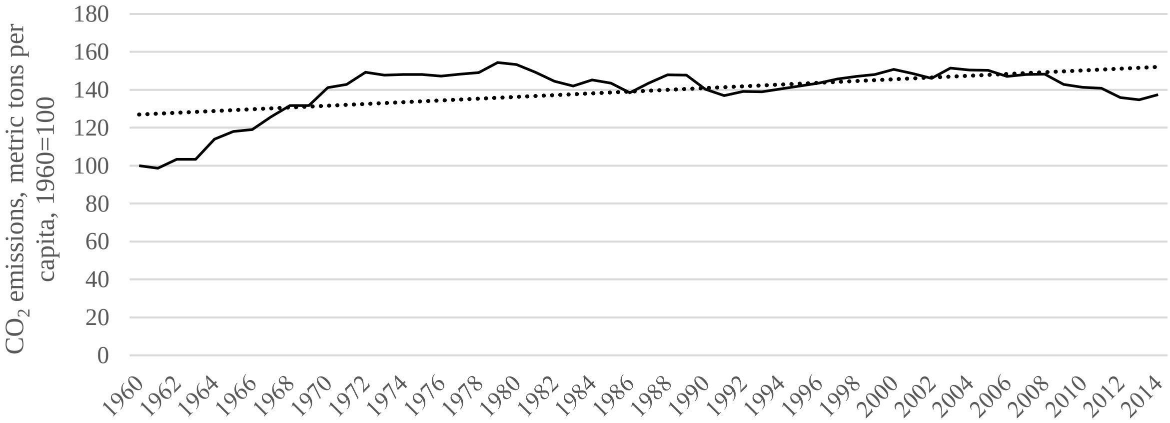

Figure 2.4 Canadian CO_2 Emissions in Absolute Terms, 1960-2014.

(Source: The World Bank, 2019a)

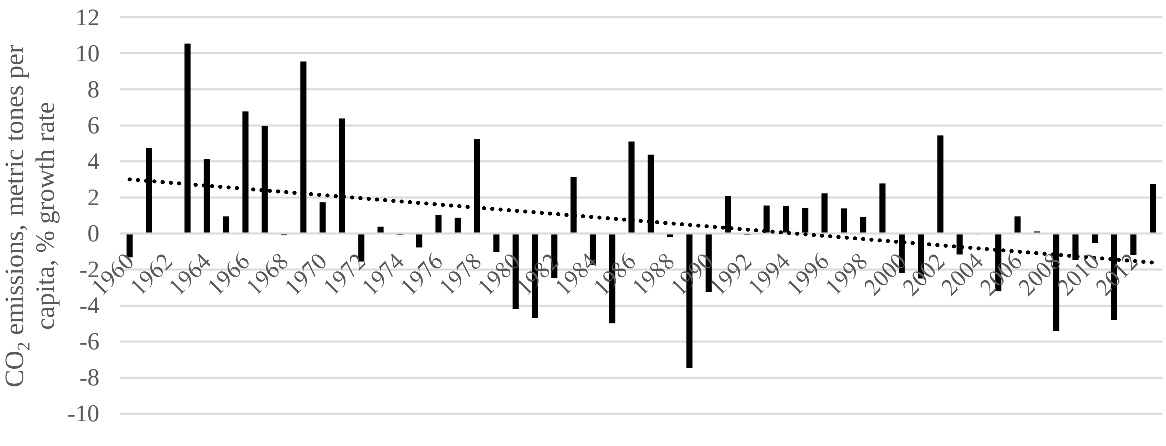

Figure 2.5 Canadian CO_2 Emissions % Growth Rate, 1960-2014.

(Source: The World Bank, 2019a)

The annual average growth rate for the period plotted is approximately 0.70% and therefore, confirms the overall increasing trend in CO_2 emissions. The Conference Board of Canada (2019) suggest that population growth may be one possible explanation for the growing trend. Other feasible justifications could be increased exports of goods such as forest products, natural gas, and petroleum. While these goods are exported, Canada still carries the cost of the GHG deriving from the production processes. Canada also remains a large emitter when the conventional carbon footprint is adjusted to not only consider emissions embodied in trade but also disparities in carbon efficiency in export sectors of various countries (Kander, Jiborn, Moran & Wiedmann, 2015).

Projections forward also paint a rather bleak picture. With the contemporary policies, GHGs are projected to continue to increase, placing Canada on a trajectory that is not in line with the Paris Agreement. In a report by Climate Transparency (2018), which relies upon, for example, the Burck, Marten, Höhne, Bals, Frisch, Clement and Szu-Chi (2018) and Climate Action Tracker (2018), one can observe Figure 2.6. As reported by the Burck, Hagen, Marten, Höhne, and Bals (2019), Canada persists in the category of very-low-performing countries, and this is because the country remains one of the largest emitters in terms of GHG in absolute as well as per capita terms. More precisely, the country is ranked very low when it comes to GHG emissions, renewable energy as well as energy use. Similarly, the Climate Action Tracker (2018) suggests that nationally determined contributions are highly insufficient since they are inconsistent with keeping global warming below 2 degrees and let alone with the stronger 1.5 degrees as stated in the Paris Agreement.

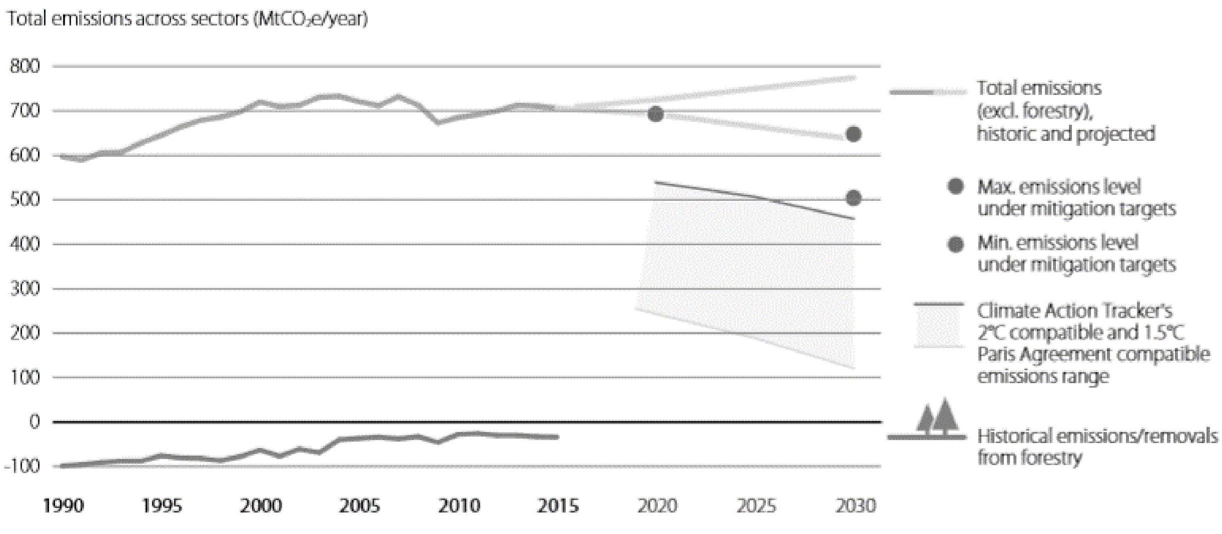

Figure 2.6 Canadian Comparability of Climate Targets with the Paris Agreement.

(Source: Climate Transparency, 2018)

In an optimal world, one could sustain economic growth and simultaneously abate emissions. Carbon intensity or emissions intensity measures this environmental-economic balance; in other words, the ratio of CO_2 emissions to GDP (Baumert, Herzog & Pershing, 2005). Reported in Figure 2.7 are the emission intensity, CO_2 emissions, and GDP for Canada over the period 1960-2014. Observed is that the emissions intensity falls by an annual average of approximately 1.25% for the period studied. However, an immense rise in GDP counteracts the falling emissions intensity and consequently increases total CO_2 emissions, thus suggesting a relative and not absolute decoupling. The divergence observed in Figure 2.6 can, according to the Environment and Climate Change Canada (2018) derive from actions such as fuel switching, increased efficiency, modernization of industrial processes as well as structural change.

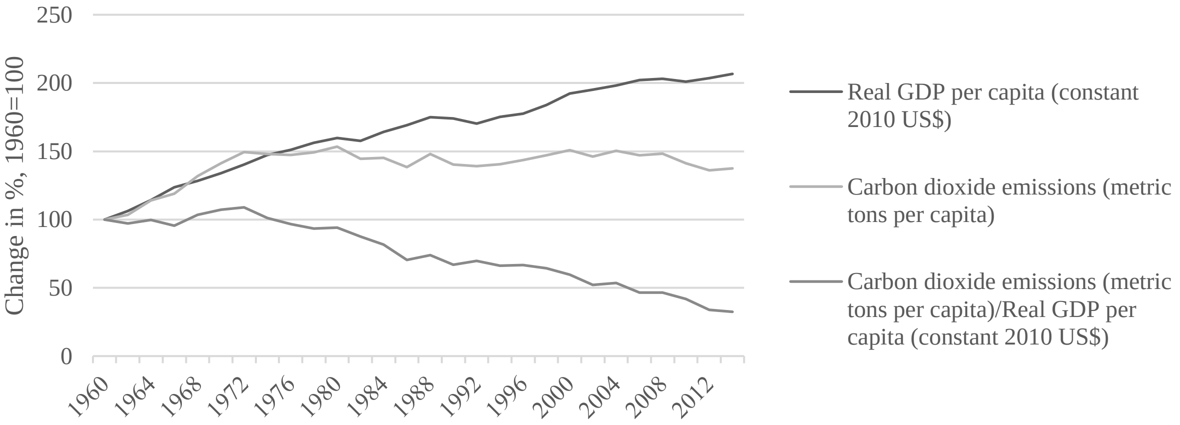

Figure 2.7 Canadian GDP per capita, CO_2 Emissions, and Emissions Intensity, 1960-2014.

(Source: The World Bank, 2019a, 2019c)

Authors own Calculation

3 Related Literature

3.1 Theory

Studied extensively is the interrelationship between economic growth and environmental degradation. One curve used as an empirical regularity is the EKC. It proposes that countries can grow first and clean up later; however, if this does not hold this sort of reasoning will create enormous environmental costs that the planet may not be able to absorb. The theoretical framework, therefore, touches upon the relationship between economic growth and environmental pollution with the primary focus being on the EKC.

3.1.1 The Environmental Kuznets Curve

Kuznets (1955) suggested that an inverted-U-curve could represent the relationship between inequality and income. From the 1990s onwards, a similar reasoning was employed to the relationship between environmental degradation and income. The EKC was first recognized by Grossman and Krueger (1991) when they investigated the relationship between sulphur dioxide and smoke with income. Their findings pointed towards a positive correlation between sulphur dioxide and income up until a turning point in which the trend switched towards a negative correlation, demonstrated in Figure 3.1. The EKC was later extended to account not only for sulphur dioxide but also for other types of environmental pollutions.

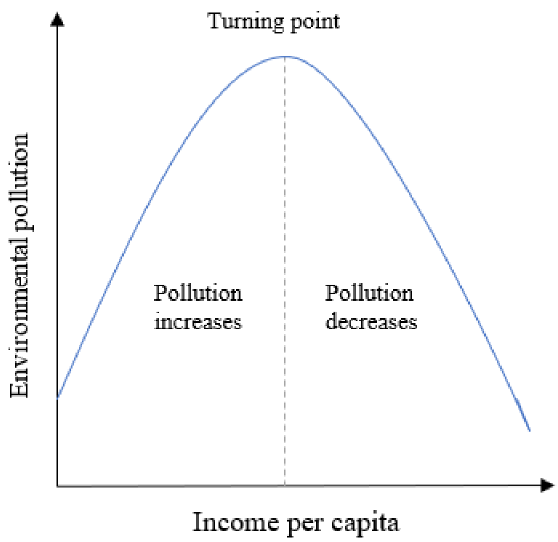

Figure 3.1 The Environmental Kuznets Curve

(Source: Grossman & Krueger, 1991)

In short, the EKC theory rests on the idea of structural transformation. As described by Dinda (2004) it is based on the shift from a rural agrarian economy towards an industrial society, as the transformation intensifies, so does environmental pollution. With economic growth, the economy once again transitions, this time toward a cleaner service economy. The phasing out of the industrial society and the shift against a more technology and service driven society may act as a counteracting factor to the previously heightened pollution and may even allow emissions to fall. Hence, when an economy has reached a certain level of development, it can sustain future growth without a proportional rise in emissions. In other words, economic growth itself may be the resolution to environmental issues (The World Bank, 1992).

Several potential mechanisms are causing the unique look behind the EKC. Grossman and Kruger (1991) themselves stress how economic growth may influence the quality of the environment through three distinct mechanisms: the scale effect, technological effect, and the composition effect. The scale effect portrays the initial negative impact on the environment that comes with economic growth. In short, economic growth results in more output and consequently, environmental degradation; however, more output also implies more inputs, and as one consumes natural resources, environmental pollution increases. Hence, environmental pollution grows through the scale effect with economic growth (Grossman & Krueger, 1991). However, the EKC hypothesis does not predict a monotonic increasing relationship between economic growth and environmental degradation. Instead, the shape of the EKC implies that there must be counteracting factors that offset the scale effect. Among those mechanisms are the technological effect, the composition effect, effects of trade, increased interest for a clean environment as well as sharper regulations.

Grossman and Kruger (1991) describe the technological effect as technological progression and efficiency gains in production. While demand for cutting-edge technology does typically not derive from environmental concerns at the firm-level one can still utilize the environmental benefits from a more efficient production, in other words, one switch old and dirty technologies for contemporary and environmentally friendly ones. Moreover, competitive markets force firms to lower prices of goods and services sold, therefore, to maximize profits firms will seek lower production costs by investing in existing efficient technologies or attempt to evolve modern technology internally. The more efficient production processes demand fewer inputs, which could yield diminishing effects on the environmental pollutions. However, technological improvements seem to follow economic growth, and this is because wealthier economies can afford to make finance research programs (Komen, Gerking, & Folmer, 1997).

Lastly, Grossman and Kruger (1991) define the composition effect as the alternation in the composition of goods and services that occur when the economy undergoes a structural transformation from an industrial society towards a more service-based economy. Two justifications can clarify the increased demand and consumption of service with economic growth. Firstly, both governments, as well as firms, have a greater need for research and development and, secondly, there is an enlarged need for professions fitting the modern society. Hence, pollution levels are not increasing, with GDP per capita. Vukina, Solakoglu, and Beghin (1999) summarize it as if one alters the composition of goods and services, then environmental pollution may not increase to scale with the country´s income growth.

However, there are other possible justifications for this inverted inverted-U-curve than those posed by Grossman and Kruger (1991). According to the Heckscher-Ohlin model, trade presents a way to enlarge domestic production by employing abundant resources effectively. In other words, each economy should specialize according to their comparative advantage, the goods that they can most efficiently and adequately generate (Krugman, Obstfeld & Melitz, 2015). Therefore, when developed economies encourage investments in research programs, employs more contemporary technologies and operates in a more service-based economy, discrepancies arise in the preconditions of trade among developed economies and developing ones. As a result, less developed economies often become owners of "dirty" and material intensive productions while developed ones specialize in less pollution- and service-intensive productions (Jänicke, Binder & Mönch, 1997; Stern, Common & Barbier, 1996).

Two similar hypotheses regarding trade exist in which there is no fundamental difference. The displacement hypothesis proposes that developed economies reallocate their dirty industries to less developed countries. Similarly, the pollution haven hypothesis suggests that one moves heavy polluting industries to economies with weaker environmental regulations. Therefore, global pollution levels do not diminish (Cole, 2004; Taylor, 2004; Halicioglu & Ketenci, 2016). Which implies that structural transformation towards a service economy may derive from the fact that the developed economies manufactures goods elsewhere, and therefore, allows someone else to bear the environmental costs. The last perspective also stresses how market size becomes enlarged with trade. On the one hand, trade may result in investments in research programs evolving energy efficient technologies which lower emissions (Shahbaz and Shabbir, 2012). On the other hand, trade may trigger unnecessary consumption due to the enlarged access to goods and services which consequently expands CO_2 emissions (Dinda, 2004, Schmalensee, Stoker & Judson, 1998; Copeland & Taylor, 2001).

Another mechanism influencing and explaining the downturn of the EKC is the expanded interest for a cleaner planet, in other words, the income elasticity of environmental quality demand (McConnell, 1997; Beckerman, 1992). Roca (2003) detects that the willingness to bear the cost of a cleaner environment increases with income: at a certain level, willingness to pay for a healthier environment rises relatively faster than income. The increased interest in the environment causes individuals to choose less pollution-intensive products, donate money to environmental organizations, and vote for environmentally focused political parties.

A last essential mechanism potentially explaining the EKC is regulation. Hettige, Dasgupta, and Wheeler (2000) argue that unless one reinforces regulations, emission will continue to grow. Politicians decide over the regulations; therefore, they are a crucial determinant whether economic growth motivates them to inflict further environmental regulations. As mentioned above, as income grows, individuals tend to demand a cleaner environment. Therefore, the median voter theorem, evolved by Black (1948), could aid in clarifying what politicians will do, given that the economy is a democracy. More precisely, Black (1948) suggests that for a politician to maximize its votes, it should implement a political agenda by the median voter. Hence, this line of reasoning could help explain why leaders in nations with growing economies strengthen their environmental regulations.

3.1.2 Limitations of the Environmental Kuznets Curve

While being an empirical regularity, some scholars emphasize how the EKC does not apply to all forms of pollutants. Authors such as Harbaugh, Levinson, and Wilson (2002) stress how several substantial pollutants only depict limited empirical support. More precisely, the EKC hypothesis seems to apply for pollutants with local repercussions and short-term costs, for instance, sulphur dioxide and nitrogen oxides (Arrow, Bolin, Costanza, Dasgupta, Folke, Holling, Jansson, Levin, Mäler, Perrings & Pimentel, 1995; Dinda, 2004; Lieb, 2004; Ansuategi & Escapa, 2002).

Hence, the EKC hypothesis does not seem to hold for pollutants that impose long-term and spread costs (Arrow et al. 1995; Dinda, 2004). These types of pollutants are often global and with outcomes such as global warming and climate change, for instance, CO_2, methane, and nitrous oxide. Therefore, authors such as Lieb (2004) and Ansuategi and Escapa (2002) argues that motivation is lower to abate these types of pollutants, it might also give rise to free-riding issues in which nations benefit from actions taken by other others to diminish these pollutions. In other words, global emissions are an example of the tragedy of commons theory by Hardin (1968) in which countries act according to their own needs rather than the world´s collective interest.

Another considerable criticism is that the observed EKC for individual countries may not happen on a global level as touched upon above. According to Arrow et al. (1995), a descending pollutant may spur other emissions or reallocations of emissions to other parts of the world. Also, Dinda (2004) and Andreoni and Levinson (2001) stress the lack of a global EKC. If individual countries drive down their emissions by pollution displacement, the measures of environmental advancements will not be indefinitely replicable, because the least developed economies will not have the potential to export their pollutants since there will be none less developed than themselves.

Others have stressed that the EKC hypothesis may not hold in the long-run (Dinda, Coondoo, & Pal, 2000). Some scholars, instead of the EKC, propose an N-shaped relationship between income and pollutants, hence, proposing a re-linking hypothesis (de Bruyn & Opschoor, 1997; Bengochea-Morancho & Martínez-Zarzoso, 2004; Friedl & Getzner, 2003). Similarly, Gill, Viswanathan, and Hassan (2017; 2018) concludes that several studies establish evidence of CO_2 emissions rising at ever decreasing rates and that the turning point of global pollutants may be excessively out of possible income levels.

Furthermore, Dasgupta, Laplante, Wang, and Wheeler (2002), as well as Perman and Stern (2003), highlights three other relationships among emissions and income over the traditional EKC, seen in Figure 3.2. Firstly, "new toxics" assumes the curve to be monotonic, this is because new forms of pollutants replace the old ones, and while the old ones comply to the inverted-U-curve the new ones do not. Examples of these new types of emissions are, for instance, CO_2. While abating old forms of emissions, new ones come into existence, so the net impact remains positive. Similarly, the "a race to the bottom" curve assumes a monotonic EKC and derives from the displacement and pollution haven hypothesis. Lastly, the revised EKC supports the traditional inverted-U-curve, and it assumes that developing will have the power to conduct environmental improvements and therefore their EKC will peak at a lower level than in those economies that have developed before them.

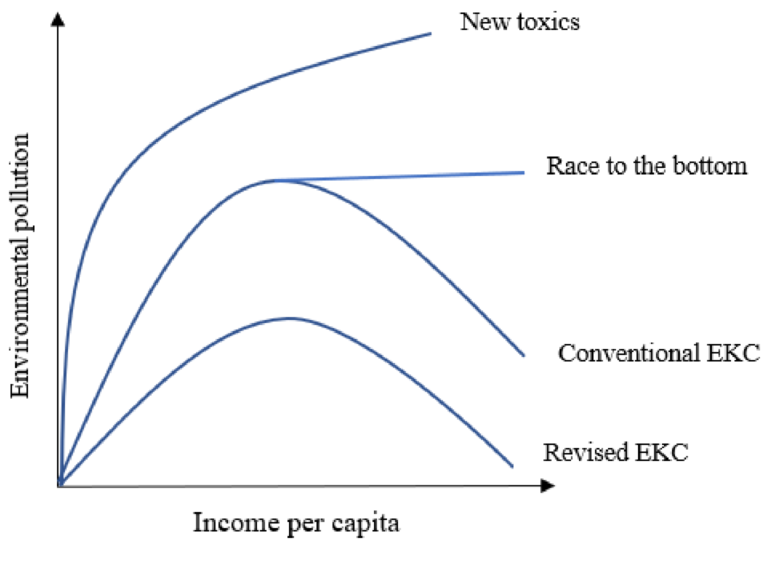

Figure 3.2 The Environmental Kuznets Curve, Alternative Views

(Source: Dasgupta, Laplante, Wang & Wheeler, 2002; Perman & Stern, 2003)

Lastly, some scholars criticize the econometrics and estimation methods used. Gill, Viswanathan, and Hassan (2018) stress how existing studies regularly is not robust econometrically; arguing that results are usually highly sensitive to the model´s functional form and the specification of the variables. Examples of shortcoming these studies might suffer from are, omitted variable bias and problems of model adequacy. Similar criticism can be found in studies such as Stern (2004), Müller-Fürstenberger and Wagner (2007), Hill and Magnani (2002), Dinda (2004), Copeland and Taylor (2004) which also points towards issues such as omitted variable bias, stationarity of the variables, lack of robustness checks as well as poor methodology.

3.2 Previous Research

Although the criticism raised the EKC hypothesis is still widely applied in research, particularly within the environmental pollution – growth – energy nexus as will be seen below. Since there might not be a clear connection between higher income and diminishing CO_2 levels, it is of great relevance to control for other possible variables that might explain its trajectory. This section, therefore, contains six smaller sub-sections highlighting studies investigating the relationship between economic growth and environmental pollution accounting for various factors that might affect emissions, ending with previous studies on Canada.

Firstly, the literature review covers economic growth – energy consumption nexus. Secondly, the economic growth – environmental pollution nexus. Thirdly, the energy – output – environment nexus. Fourthly, trade is introduced into the environmental function. Fifthly, the discussion extends to include urbanization. Sixthly, financial development is proposed as a new important mechanism in the environmental framework. Lastly, this literature review covers research on the EKC in Canada.

3.2.1 Economic Growth and Energy Consumption

One of the first strands within the energy literature touches upon the relationship between energy consumption and economic growth and has become extensively researched since the original study by Kraft and Kraft (1978). However, the existing studies arrive at inclusive empirical results, which is best explained by the various econometric methods implemented (Chontanawat, Hunt & Perse, 2008; Shahbaz & Lean, 2012). As emphasized by Ozturk and Acaravci (2010) and Payne (2010), ambiguous results do not act as useful tools for policy-making authorities in setting up a wide-ranging energy agenda to sustain long-run economic growth. Similarly, Ghali & El-Sakka (2004) stress the relevance of possessing proper insight in the causal links among the variables both from a theoretical- and policy-point of view.

Studies such as Payne (2010) and Ozturk (2010) reviews and summarizes literature on the economic growth – energy consumption nexus and derives four hypotheses. Firstly, the growth hypothesis, in which energy consumption Granger causes economic growth. In this case, one should avoid energy reduction policies and instead explore new energy sources. Secondly, the conservation hypothesis, economic growth Granger causes energy consumption; in other words, economic growth seems to be independent of energy consumption; therefore, can energy conservation policies be implemented. Thirdly, the feedback hypothesis, suggests that there is bidirectional causality between energy consumption and GDP. An increase in economic growth results in a rise in energy consumed, which consequently results in economic growth. Similarly, to the first hypothesis, energy conservation policies should be discouraged. Lastly, the neutrality hypothesis applies when no causal relationship can be established among the variables. Like the feedback hypothesis, energy reduction policies may have small or no impact on economic growth.

3.2.2 Economic Growth and CO_2 Emissions

The second strand of literature studies and provides evidence on the economic growth – emissions nexus, in other words, the EKC, here focusing on CO_2 emissions. However, as suggested above, the EKC might not hold for CO_2 emissions. Authors such as Shafik (1994), Holtz-Eakin and Selden (1995) and Roberts and Grimes (1997) among others, studies the relationship between CO_2 emissions and income and cannot confirm the EKC hypothesis. For instance, Holtz-Eakin and Selden (1995) and Shafik (1994), instead, stress how CO_2 emissions increase monotonically with income. Similarly, more recent studies fail to find support for the EKC. For instance, Friedl and Getzner (2003) Martínez-Zarzoso and Bengochea-Morancho (2004), argues instead that the relationship of the variables is N-shaped. Others fail to establish a turning point (Richmond & Kaufmann, 2006). Similarly, Dinda and Coondoo (2006) applying panel data concludes that the interrelation between CO_2 emissions and income is ambiguous. Contemporary studies such as Al-Mulali, Saboori, and Ozturk (2015) and Farhani and Ozturk (2015), for instance, also do not find support for the existence of the EKC when studying Vietnam and Tunisia respectively.

While there are studies not supporting an EKC when studying the relation between CO_2 emissions and income, there are also those that do confirm its existence. Several studies confirm the existence of the EKC when applying panel data, for instance, Galeotti and Lanza (2005), for OECD and non-OECD economies; Bilgili, Koçak, and Bulut (2016) for 17 OECD countries; Apergis, (2016) examining 15 different countries in the world; Al-Mulali and Ozturk (2016) for 27 advanced economies; Jebli, Youssef, and Ozturk (2016) for 25 OECD countries; Omri, Rault and Chaibi (2015) for Middle East and North African countries; and Tamazian, Chousa, and Vadlamannati (2009) for the BRIC countries. Similarly, but applying time series data Ang (2007), Jalil and Mahmud (2009), Ozturk and Acaravci (2013), Shahbaz, Tiwari, and Nasir (2013) and Boutabba (2014) finds evidence for the EKC in various countries.

Hence, the empirical results are at best, mixed for the EKC hypothesis. If it holds income is not only the cause but also the answer to environmental issues, however, if it cannot be supported these types of studies fail to derive at an answer to the most critical issue facing us. It is, therefore, essential to incorporate other potential variables that may influence CO_2 emissions.

3.2.3 Economic Growth, Energy Consumption, and CO_2 Emissions

Emissions are highly interlinked to the amount of energy consumed, the higher the carbon content of the fuel mix, the higher the CO_2 emissions. On the one hand, energy consumption may spur more elevated levels of emissions, and on the other hand, it may cause economic growth. Meaning that reducing energy consumption to make emissions fall might not be as straightforward (Ang, 2007; Apergis & Payne, 2009, 2010; Acaravci & Ozturk, 2010; Farhani & Ozturk, 2015). Since the variables are interdependent, one should account for them under a single framework. By incorporating energy consumption into the original EKC framework, the interest of studying the inverted-U-relationship begins to surge within the energy literature. For instance, Soytas, Sari, and Ewing (2007) explores the US, Zhang, and Cheng (2009) as well as Wang, Zhuo, Zhou, and Wang (2011) investigates China, Salahuddin, and Gow (2014) studies the Gulf Cooperation Council countries, and Baek (2015) focuses on the Arctic countries.

More precisely, Ang (2007) was one of the firsts scholars to place the economic growth – energy use nexus and the economic growth – environmental pollution nexus under a single multivariate framework. Ang (2007), therefore studied the dynamic relationship between CO_2 emissions, energy use, and real GDP in France for the period 1960-2000. The empirical evidence supports not only the EKC hypothesis but also confirms a long-run relationship among the variables. More precisely, the results indicate that economic growth Granger causes energy consumption and CO_2 emissions in the long-run, however, in the short-run, only a unidirectional causal link is established from growth in energy to output growth.

Following Ang (2007), Apergis and Payne (2009, 2010) investigate the energy – output – environment nexus. However, in contrast to Ang (2007) they do so by applying panel data for firstly, six Central American economies for the period 1971-2004, and secondly, for eleven economies of the Commonwealth of Independent States for the period 1992-2004. By adopting a VECM, the authors find support for the EKC hypothesis and a statistically significant and positive effect of energy use on emissions. Moreover, the results indicate bidirectional causality between energy use and CO_2 in the long-run, which implies that the studied countries have not decarbonized their fuel mixes. Whereas in the short-run there is bidirectional causality among energy use and real output as well as unidirectional causality from energy use and real output to pollutions.

Applying similar variables Acaravci and Ozturk (2010) examine 19 selected European economies for the period 1960-2005. In contrast to Ang (2007) and Apergis and Payne (2009, 2010) the authors apply an ARDL bounds testing approach to cointegration and can, therefore, conclude that out of the eleven countries investigated only seven countries (Denmark, Germany, Greece, Iceland, Italy, Portugal, and Switzerland) have a long-run relationship among the variables. The long-run estimates suggest that energy consumption positively relates to pollution levels in Denmark, Germany, Greece, Italy, and Portugal. The EKC is also supported in the case of Denmark and Italy but not in the other countries under study.

Similarly, Lean and Smyth (2010) study a panel of five ASEAN countries for the period 1980-2006. The authors not only confirm the EKC hypothesis but also establishes that energy consumption affects CO_2 emissions positively in the long-run, as seen in other cases above. When considering causality, the findings propose that in the short-run a unidirectional causal link exists from pollutions to energy use, whereas in the long-run, there is unidirectional causality from CO_2 emissions and energy use to real output.

Arouri, Youssef, M´henni, and Rault (2012) state how their study builds and extends from findings in Liu (2005), Ang (2007), Apergis and Payne (2009) and Payne (2010). The authors, therefore, suggest a bootstrapping panel unit root test but also cointegration approaches to investigate the causal relationships. They do so for twelve Middle East and North African economies for the period 1981-2005. Similarly, authors such as Lean and Smyth (2010) they find support for the EKC and establishes a long-run relationship between emissions and energy consumption.

However, it could be the case that the control variable energy consumption explains most of the relation to CO_2 emissions due to their interdependence, thus driving the results. The studies mentioned above fail to consider this aspect and therefore, do not control for this possibility; one might there question the strength of their models. Furthermore, observed is that the various studies reach ambiguous results regarding the impacts of the different variables on environmental degradation. There are numerous reasons for these differing results among them are, sample selection bias, the choice of econometric techniques or in other words, the selection of functional form, as well as omitted-variable bias issues.

A remedy for omitted-variable bias is to control for other variables that have the potential to influence CO_2 emissions, therefore, multiple studies account for various variables, for example, trade, financial development, and urbanization (Komal & Abbas, 2015; Al-Mulali, Saboori, Ozturk, 2015; Farhani & Ozturk, 2015; Tamazian, Chousa & Vadlamannati, 2009). In other words, different aspects of the economy should be accounted for when analyzing the relationship between income, income squared, energy use, and environmental pollution, testing whether the EKC hypothesis holds (Dogan & Turkekul, 2016).

3.2.4 Economic Growth, Energy Consumption, Trade, and CO_2 Emissions

Therefore, the literature incorporates trade into the models. As stress above, trade may influence CO_2 emissions both positively and negatively. Within the existing literature one can spot several attempts to investigate the environmental function while accounting for trade, for instance Ang (2009), Halicioglu (2009), Jalil and Mahmud (2009), Jayanthakumaran, Verma, and Liu (2012), Farhani, Chaibi and Rault (2014) among others have attempted this. More precisely, Ang (2009) studies the Chinese pollution function for the period 1953-2006 under a modified EKC framework having CO_2 emissions as an endogenous variable and GDP, energy consumption, and trade as exogenous ones. Ang (2009) conclude that energy, consumption, GDP, and trade all result in higher CO_2 emissions.

Similarly, Halicioglu (2009), focusing on Turkey 1960-2005, examines the dynamic causal relationships between CO_2 emissions, income, energy use, and trade. By adopting the bounds testing approach to cointegration the authors confirm two long-run relationships firstly, CO_2 emissions have a long-run relationship with all other variables, and similarly, income has a long-run relationship with the variables in the model. Halicioglu (2009), furthermore, utilize Granger causality tests which suggest that GDP, energy consumption, and trade can explain CO_2 emissions, especially emphasizing the crucial role that GDP might play in lowering emissions.

In the same way, Jalil and Mahmud (2009) study China for the period 1975-2005. However, accounting for a different set of variables compared to Ang (2009), and extending the methodology applied by Halicioglu (2009). To study the EKC hypothesis, Jalil and Mahmud (2009) uses a quadratic relationship among GDP and CO_2 emissions and finds support for the EKC. In addition, GDP and energy consumption influences emissions, whereas trades impact remains insignificant in the long-run. Jalil and Mahmud (2009) similarly to authors above tests causality, and in contrast to Halicioglu (2009), the authors only establish one causal link running from GDP to CO_2 emissions.

Jayanthakumaran, Verma, and Liu (2012), moreover, test the long-run and the short-run relationships for this modified EKC framework for both China and India over the period 1971-2007 by applying the ARDL bounds testing approach to cointegration. Due to the sensitivity of this method to structural breaks, these authors, unlike the authors mentioned above, accounts for endogenously determined structural breaks. By doing so Jayanthakumaran, Verma and Liu (2012) conclude that structural changes, energy consumption as well as real GDP determine CO_2 emissions in China, whereas, in India, no causal relationships are established.

More recently, Farhani, Chaibi, and Rault (2014) extend this literature by studying Tunisia for the period 1971-2008 by applying the ARDL bounds testing approach to cointegration. By doing so, the authors not only establish two causal long-run relationships but also finds support for three unidirectional causal relationships, in which GDP, GDP squared, and energy consumption individually Granger-causes CO_2 emissions.

However, the studies highlighted above only consider functions of the global economy. Therefore, the fact of whether the countries import pollution-intensive goods or exports them is hidden in the analyses. These sorts of questions have laid the foundation to a different type of study, for instance, Kander, Jiborn, Moran, and Wiedmann (2015) and Baumert, Kander, Jibron, Kulionis, and Nielsen (2019) to mention a few.

3.2.5 Economic Growth, Energy Consumption, Trade, Urbanization, and CO_2 Emissions

An additional variable introduced into the EKC framework is urbanization. Hossain (2011), Sharma (2011) as well as Farhani, Shahbaz, and Arouri (2013) all emphasize the relevance of its inclusion. On the one hand, urbanization may drive CO_2 emissions up as a result of more pollution intensive consumption. On the other hand, urbanization may spur an overhauling towards modern fuels. Furthermore, there is a higher chance to realize economies of scale and to utilize natural resources more efficiently. The structure of cities is, therefore, essential for sustainable development (Martínez-Zarzoso & Maruotti, 2011). Yet, only a limited number of studies accounts for urbanization while studying the relationship between CO_2 emissions, energy consumption, economic growth, and trade (Hossain, 2011; Sharma, 2011; Farhani, Shahbaz & Arouri 2013; Kasman & Duman, 2015).

The study produced by Hossain (2011), tests the dynamic relationship between emissions, energy consumption, GDP, trade, and urbanization for a panel consisting of newly industrialized countries for the period 1971-2007. While the authors cannot confirm any long-run causal relationships, they establish multiple unidirectional relationships in the short-run. Firstly, a unidirectional relationship from real output and trade to emissions, secondly, from real GDP to energy consumption, thirdly, from trade to urbanization, fourthly, from urbanization to GDP, and lastly, from trade to real output.

Similarly, Sharma (2011) scrutinizes the determinants of $CO_{2,}$ accounting for the same variables as Hossain (2011), but for a panel including 69 countries all over the world for the period 1985-2005. The author´s findings suggest that while urbanization drives CO_2 emissions down, GDP per capita, trade, and energy consumption all causes the emissions to rise.

In contrast, Farhani, Shahbaz, and Arouri (2013) parallel two types of models. Firstly, a model which accounts for both energy consumption, GDP, and trade, observed in, for instance, Halicioglu (2009) and Jalil and Mahmud (2009), among others. Secondly, a model that, in addition to the variables mentioned above, also accounts for urbanization to avoid omitted-variable bias, such as proposed by Hossain (2011). By applying a fully modified ordinary least squares for the two different models over the period 1980-2009 for 11 Middle East and North African countries, Farhani, Shahbaz and Arouri (2013), find evidence that supports the EKC hypothesis as well as stress how the variables affect CO_2 emissions.

Kasman and Duman (2015) similarly to Farhani, Shahbaz, and Arouri (2013) applies a fully modified ordinary least squares, differentiating these studies from Hossain (2011) and Sharma (2011). They study new European Union members as well as candidates using panel data for the period 1992-2010. The authors conclude that the EKC hypothesis is applicable. Moreover, the result suggests that trade and urbanization positively relate to emissions. When testing for causality, the authors find, for instance, a unidirectional causality from energy use, trade, as well as urbanization to CO_2 emissions.

3.2.6 Economic Growth, Energy Consumption, Trade, Urbanization, Financial Development, and CO_2 Emissions

Financial development is a mechanism that is more recently introduced in the environmental function, observed in, for instance, Jalil and Feridun (2011), Ozturk and Acaravci (2013), Tang and Tan (2014) to mention a few. According to Tamazian, Chousa, and Vadlamannati (2009), financial development may both positively and negatively affect the environment. Firstly, financial development may result in reduced financing costs, therefore enlarging the possibilities of investments and consumption and consequently energy use and CO_2 emissions.

However, financial development can cut energy consumption and emissions by allowing one to more easily obtain loans necessary to make investments improving energy- and business performance-efficiency, similarly, one can avoid "dirty industries" (Tamazian, Chousa and Vadlamannati, 2009; (Grossman & Krueger, 1995; Halicioglu, 2009). Although a more limited amount of studies on this topic, the conclusions differ, some suggest that financial development increases energy consumption and CO_2 emission (Sadorsky, 2010; Zhang, 2011; Islam, Shahbaz, Ahmed & Alam, 2013; Tang & Tan, 2014). Others find the reverse (Tamazian, Chousa & Vadlamannati, 2009; Tamazian & Rao, 2010; Shahbaz, Hye, Tiwari & Leitão, 2013; Jalil & Feridun, 2011) and some do not establish any significant impact (Ozturk & Acaravci, 2013).

More precisely, Jalil and Feridun (2011) tests the dynamic relationship between CO_2 emissions, energy consumption, economic growth, trade openness and financial development (proxied by the ratio of liquid liabilities to GDP, private sector loans to the nominal GDP, the ratio of commercial bank assets to the sum of commercial bank and central bank assets, foreign assets plus foreign liabilities as a share of GDP, and foreign direct investments) for China during the period 1953-2006. When applying the ARDL bounds testing approach for cointegration, the authors find evidence for the EKC hypothesis; they moreover conclude that the recently added variable, financial development, do not positively impact CO_2 emissions in the long-run whereas the other variables do.

By applying a similar method to Jalil and Feridun (2011), but with a different proxy for financial development (domestic credit to the private sector as a share of GDP) Ozturk and Acaravci (2013) investigates Turkeys determinants for CO_2 for the period 1960-2007. The testing implies that the EKC hypothesis holds, moreover trade results in higher levels of CO_2 emissions in the long-run, whereas financial development does not significantly impact CO_2 emissions.

In contrast to Jalil and Feridun (2011) and Ozturk and Acaravci (2013), Tang and Tan (2014) studies the interconnections of energy consumption, economic growth, relative price, foreign direction investment, and financial development for Malaysia for the period 1972-2009 using both the Johansen-Juselius cointegration test and the bounds testing approach to cointegration. Hence, not considering CO_2 emissions explicitly. Moreover, the authors proxy financial development by constructing an index of the ratio of money and quasi money to GDP, the ratio of liquid liabilities to GDP, the ratio of domestic credit to the private sector as a share of GDP, and the ratio of domestic credit provided by the banking sector to GDP. By doing so, they conclude that financial development, foreign direct investment, and GDP positively affects energy consumption in the long-run.

However, only a few studies account for energy consumption, GDP, trade, urbanization and financial development simultaneously (Al-Mulali, Tang & Ozturk, 2015; Farhani & Ozturk, 2015; Dogan & Turkekul, 2016; Saidi & Mbarek, 2017). More precisely, Al-Mulali, Tang, and Ozturk (2015) study a panel in which the countries are divided into four classifications depending on income level using a dynamic ordinary least squares method and proxying financial development with domestic credit to the private sector as a share of GDP. The authors draw five significant conclusions. In all classifications, energy consumption results in CO_2 emissions, whereas financial development contracts CO_2 emissions. Furthermore, urbanization has a negative impact on CO_2 emissions and GDP positive in three classifications. Lastly, trade openness has differing effects in differing classifications, in one trade has an insignificant effect, whereas in two classifications it has a significant negative impact and in the last one, it positively relates to CO_2.

In contrast, Farhani and Ozturk (2015) apply an ARDL approach to study the relationship of the variables in Tunisia for the period 1971-2012, proxying financial development with domestic credit to the private sector as a share of GDP. Not only do the authors fail to find support for the EKC, but they moreover conclude that all variables drive CO_2 emissions. When conducting a Granger causality test Farhani and Ozturk (2015) establish that GDP, energy use, financial development, trade, and urbanization Granger-causes CO_2 emissions in the long-run, however, CO_2 emissions, GDP, energy use, trade, and urbanization also Granger causes financial development.

Applying a similar method and variables to Farhani and Ozturk (2015), Dogan and Turkekul (2016) study the US for the period 1960-2010. They establish a long-run relationship between the variables studied and the long-run estimates suggest that financial development has an insignificant effect on CO_2 emissions, energy use, and urbanization positive and trade negative. Their study does not support the EKC hypothesis. Furthermore, the short-run causality tests imply that there exists multiple bidirectional causality links more specifically between, CO_2 and GDP, CO_2 and energy use, CO_2 and urbanization as well as GDP and trade Moreover, the results suggest three unidirectional causal links, firstly, from output to energy use, secondly, from financial development to GDP, thirdly, from urbanization to financial development.

More recent studies by for instance Saidi and Mbarek (2017) also examines the dynamic relationship between CO_2 emissions, GDP, GDP^2, trade, urbanization and financial development (proxied by domestic credit to the private sector by banks as a share of GDP) however for 19 emerging economies for the period 1990-2013. The authors establish that both GDP and GDP^2 increases CO_2 emissions; hence, not supporting the EKC. Furthermore, financial development and urbanization portray a negative relationship to CO_2 emissions. The differing results of the studies may derive from the choice of country/region and how developed it is, the estimation strategies, methods, models applied, the proxies used, as well as the characteristics of the data and its quality.

3.2.7 The Canadian Economic Growth, Energy Consumption, and CO_2 Emissions

Only a fraction of all studies within the EKC framework concentrate solely on Canada. To the knowledge of the author, only two studies focus purely on the Canadian CO_2 levels. Firstly, Lantz and Feng (2006) apply a panel for 5 Canadian regions over the period 1970-2000 and concludes that CO_2 is not interrelated with GDP, while population and technology is. Secondly, He, and Richard (2010) cannot establish any clear evidence for the EKC. However, the oil shock in the 1970s was crucial for the transition towards more efficient technologies and production processes.

Instead, panel studies more often consider Canada, suggesting that its emissions do follow and inverted-U-curve. For instance, Unruh and Moomaw (1997) emphasize that although Canada has gained from the technological advancements taking place after the oil crisis, the Canadian CO_2 levels continued to trend upwards after 1973, which the authors argue is due to their abundant oil resources. Moreover, Moomaw and Unruh (1997) confirm that the EKC is present in Canada, possibly explained by the oil shock, furthermore, the authors argue that the turning point is above those of the other countries in their study. Similarly, Dijkgraaf and Vollebergh (2005) find support for the EKC hypothesis in Canada when investigating CO_2. However, these studies apply few, or none additional variables, allowing for more control variables will significantly influence the estimation results as will be seen below.

4 Empirical Framework

4.1 Econometric Specification

4.1.1 Data

To econometrically test and statistically support the trends portrayed for Canada in the background chapter, this paper applies yearly data for the period 1960-2014. Consequently, this study utilizes the most extended time series accessible in the World Bank Development Indicators to obtain data for the variables suggested in Section 3. CO_2 is the carbon dioxide emissions (metric tons per capita), *GDP* is the real gross domestic product per capita (constant 2010 US$), GDP^2 is the square of real gross domestic product per capita (constant 2010 US$), included to capture the EKC. Furthermore, *EC* is the energy consumption (kg of oil equivalent per capita), *URB* is the urban population (% of total population), *TR* is the trade openness, measured as the sum of exports and imports of goods and services (% of GDP), and lastly, *FD* stands for financial development, measured by domestic credit to the private sector (% of GDP).

To overview changes occurring in the trends of each time series, an index is constructed to portray each of the variables in a similar scale applying 1960 as the base year. The graphs illustrated in Figure 4.1 suggests that all variables experience a positive trend throughout time, some more significantly than others. Most interestingly are the indications that energy consumption and CO_2 share similar trends, thus implying that these variables interact; however, formal testing is necessary to establish whether this statement holds. The graphs also suggest that structural breaks might be present. Therefore, one must control for this possibility when conducting unit root testing.

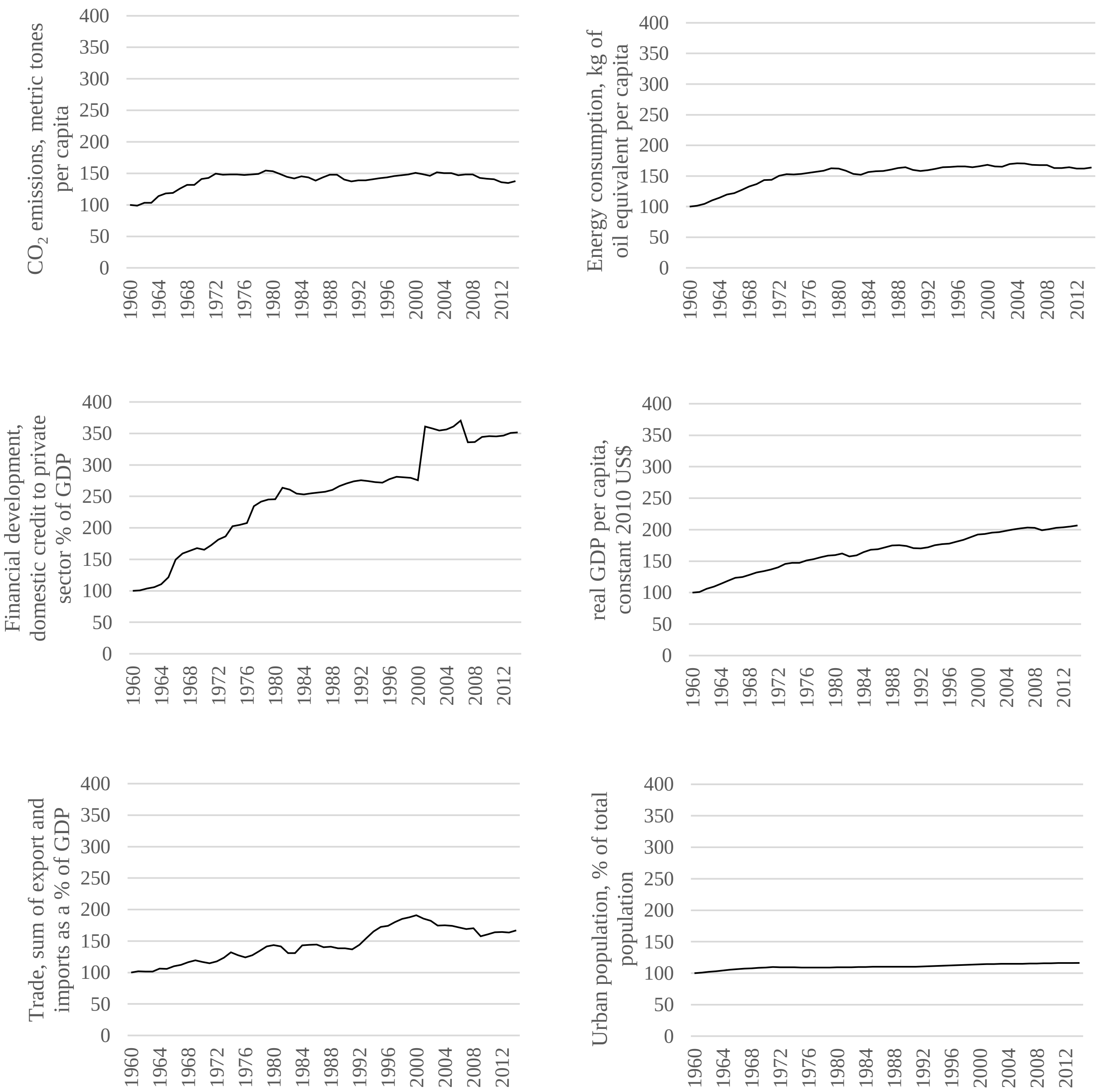

Figure 4.1 Trends of variables (before taking logarithm), 1960=100.

(Source: The World Bank, 2019a, 2019b, 2019c, 2019d, 2019e, 2019f)

4.1.2 Limitations of the Data

Firstly, this study employs time series data, which comes at the cost of not being able to generalize this is because external validity is compromised at the expense of internal validity. Drawing general suggestions for other regions and nations from this case study and its conclusions may yield not only questionable but also incorrect recommendations. Therefore, to make use of the results and to draw implications for other regions/countries, one must account for the differing country-specific characteristics. To overcome this issue, one should instead implement a panel approach; this would moreover enhance the number of observations.

Another limitation is the period studied. It is possible that many developed economies might have turned their EKC before the 1970s. While this study employs data from the 1960s and onwards, a broader timespan would enhance this paper and would allow it to better account for the EKC hypothesis. However, for this study, it proved to be challenging to identify and adopt data over a more extended period than the one studied since some variables lacked data before the 1960s. A plausible solution could have been to choose more frequent data, for instance, monthly or quarterly since this would have extended the number of observations. However, this too would prove to be difficult since such type of data was not available for the same period and all variables.

Furthermore, employing domestic credit to the private sector as a proxy for financial development may be questioned since it focuses only on the private sector and its investments. The possibility to obtain financing for environmental projects may be particularly of relevance for governments because a great deal of the environmental protection, in the end, will be a public sector activity (Tamazian, Chousa & Vadlamannati, 2009). However, the same reasoning applies to the private sector, if the financial sector is sufficiently advanced loans can more easily be obtained and may spur the investments needed for an energy transition. An environment with higher financial development allows firms to access loans necessary to avoid the so-called "dirty industries" that creates emissions (Grossman & Krueger, 1995; Halicioglu, 2009). Furthermore, studies such as Talukdar and Meisner (2001) suggest that the more the private sector is involved, the lower is the environmental degradation. In addition, Hayes and von Bülow (2018) stress how the private sector wants to steer financing towards clean energy innovations; one should, therefore, capitalize on this trend.

Lastly, the financial development variable has missing data from 2009-2014. One approach to deal with missing observations is ignoring them; however, this may produce biased results and loss of power due to a smaller dataset (Bennett, 2001), and is, therefore, not an optimal solution since the sample size is already limited. A better alternative is imputation, meaning that estimated values replace missing ones (Barista & Monard, 2003). This paper, therefore, links the data obtained through the World Bank with data on credit to the private sector (% of GDP) from the Bank for International Settlements, adjusting these data points to the World Bank level.

4.1.3 Model Specification

This study will derive from the empirical model used in Ang (2007) that merges the economic growth – environmental pollution nexus with the economic growth – energy consumption nexus into a multivariate framework. Ang (2007) specified the following model:

$$(CO_2)_t = \beta_0 + \beta_1 GDP_t + \beta_2 GDP_t^2 + \beta_3 EC_t + e_t$$

(Equation 1)

By integrating energy consumption into the environmental function, the relationship among the variables becomes vastly scrutinized. However, these studies may suffer from omitted variable bias. Therefore, more recent studies control for various aspects of the economy. As a result, studies incorporate variables such as urbanization and trade into the environmental function (Halicioglu, 2009; Jalil & Mahmud, 2009; Hossain, 2011; Sharma, 2011; Farhani, Shahbaz & Arouri, 2013). These studies, therefore, suggest that income, energy consumption, trade, and urbanization may impact CO_2 emissions. Consequently, one extends Eq.1 as follows:

$$(CO_2)_t = \beta_0 + \beta_1 GDP_t + \beta_2 GDP_t^2 + \beta_3 EC_t + \beta_4 URB_t + \beta_5 TR_t + e_t$$

(Equation 2)

Furthermore, Al-Mulali, Tang, and Ozturk (2015), Farhani and Ozturk (2015) as well as Dogan and Turkekul (2016) extends Eq.2 further by accounting for financial development. Similarly, this study suggests that income, energy consumption, trade, urbanization, and financial development determines emissions. Therefore, the following model is specified:

$$(CO_2)_t = \beta_0 + \beta_1 GDP_t + \beta_2 GDP_t^2 + \beta_3 EC_t + \beta_4 URB_t + \beta_5 TR_t + \beta_6 FD_t + e_t$$

(Equation 3)

Lastly, Eq3. is transformed into natural logarithms for statistical reasons, for instance, to reduce potential problems of heteroscedasticity. Hence, leading to the following specification:

$$(lnCO_2)_t = \beta_0 + \beta_1 lnGDP_t + \beta_2 lnGDP_t^2 + \beta_3 lnEC_t + \beta_4 lnURB_t + \beta_5 lnTR_t + \beta_6 lnFD_t + e_t$$

(Equation 4)

Here t represents time, e represents the error term, and $\beta_1, \beta_2, \beta_3, \beta_4, \beta_5$, and β_6 portrays the long-run elasticities of CO_2 emissions with respect to each of the individual variables. However, it could be the case that the control variable energy consumption explains most of the CO_2 emissions. To overcome this issue, following Tamazian, Chousa, and Vadlamannati (2009) as well as Jalil and Feridun (2011), one tests Eq.4 without energy consumption included. As a result, the model specification is as follows:

$$(lnCO_2)_t = \beta_0 + \beta_1 lnGDP_t + \beta_2 lnGDP_t^2 + \beta_3 lnURB_t + \beta_4 lnTR_t + \beta_5 lnFD_t + e_t$$

(Equation 5)

4.1.4 Hypotheses

The predicted signs of the variables under study varies. Under the EKC hypothesis, one would expect the sign of β_1 to be positive, while β_2 is expected to be negative. However, if β_2 turns out statistically insignificant one would expect to see a monotonic increasing relationship between CO_2 emissions and GDP. Furthermore, one would expect greater economic activity to result in higher energy consumption and consequently greater levels of CO_2 emissions, hence β_3 is expected to be positive in Eq.4, however, as suggested in the background, the relationship will be positive but diminishing over time. Moreover, the expected sign of β_4 is mixed due to its dependence on economic development. However, in the case of Canada, one would expect β_4 to be negative, this is because urbanization may be considered as a proxy for modernization and one would expect environmental degradation to fall with higher levels of urbanization (Ehrhardt-Martinez, Crenshaw & Jenkins, 2002; York, Rosa & Dietz, 2003).

Similarly, the expected sign of β_5 depends on the level of economic development of the country, however, in the case of a developed economy one would expect the sign of β_5 to be negative since it is believed that developed economies turn towards the production of less pollution-intensive goods and instead, chooses to import these goods from countries with less restrictive laws regarding environmental protection (Grossman & Krueger, 1995). Lastly, the expected sign of β_6 is mixed, on the on hand, financial development may lead to investments increasing output, energy consumption and CO_2 emissions, on the other hand, financial development may adversely impact energy consumption and pollution due to its possibility of stimulating energy efficiency (Tamazian, Chouse & Vadlamannati, 2009).

4.2 Estimation Strategy

4.2.1 Autoregressive Distributed Lag Method

When conducting time series analysis, either in levels or non-stationary forms, one runs the risk of ending up with a spurious regression. A plausible approach to overcome this issue is by differencing the data and, therefore, make it stationary. However, by differencing the data, one gives up the potential to conduct any long-run analysis. Another feasible solution is to employ methods that circumvent this problem by establishing whether there exists a long-run equilibrium relationship; in other words, cointegration among the variables in the model. This paper will utilize a recent cointegration approach which has surged in popularity among researchers, known as the ARDL, introduced by Pesaran, Shin, and Smith (2001). To see an overview of the method, consult Appendix A.

The ARDL possesses numerous advantages over alternative cointegration methods. Firstly, it is suitable regardless of whether the underlying regressors are I(0), I(1) or partly cointegrated (Pesaran & Smith, 1998). Secondly, one can attain both short-run and long-run estimates of the model simultaneously. Thirdly, the ARDL is not subject to residual correlation and, therefore, are endogeneity issues less of a problem (Pesaran & Shin, 1999). Fourthly, the ARDL functions well with small sample sizes (Persaran, Shin & Smith, 2001; Narayan, 2005). Lastly, the ARDL is suitable, although explanatory variables might be endogenous. In short, the ARDL method works appropriately in both large and small sample sizes and irrespective of variables being I (0), I(1) or fractionally cointegrated, and produces unbiased and efficient estimates. The ARDL model for Eq.4 is specified as follows:

$$\begin{aligned}\Delta lnCO_{2_t} = \delta_0 &+ \sum_{k=1}^{n1} \delta_{1k}\, \Delta lnCO_{2_{t-k}} + \sum_{k=0}^{n2} \delta_{2k} \Delta lnGDP_{t-k} + \sum_{k=0}^{n3} \delta_{3k}\, \Delta lnGDP_{t-k}^2 \\ &+ \sum_{k=0}^{n4} \delta_{4k}\, \Delta lnEC_{t-k} + \sum_{k=0}^{n5} \delta_{5k} \Delta lnURB_{t-k} \\ &+ \sum_{K=0}^{n6} \delta_{6k} lnTR_{t-k} + \sum_{K=0}^{n7} \delta_{7k} \Delta lnFD_{t-k} + \gamma_1\, lnCO_{2_{t-1}} + \gamma_2 lnGDP_{t-1} \\ &+ \gamma_3 lnGDP_{t-1}^2 + \gamma_4 lnEC_{t-1} + \gamma_5 lnURB_{t-1} + \gamma_6 lnTR_{t-1} + \gamma_7 lnFD_{t-1} + u_t\end{aligned}$$

(Equation 6)

In Eq.6 Δ symbolizes first difference, δ_0 depicts the drift component, and *u* is the white noise. Moreover, the terms with $\sum$ are the dynamics of the error correction, and the last part of the equation with γ_i exemplifies the long-run relationship.

While the ARDL is superior to alternative cointegration approaches, some requirements should be fulfilled for the ARDL to work fully. Although it is not of relevance whether the order of integration is, I(0), I(1), or partially cointegrated, the ARDL framework will not work correctly if the variables have an integration order higher than one, for instance, I(2) (Pesaran & Smith, 1999). Furthermore, the ARDL is sensitive to structural breaks.

To validate the maximum integration order of the variables, this paper adopts the Augmented Dickey-Fuller (ADF) unit root test presented by Dickey and Fuller (1979). However, a short-coming of this standard unit root test is its inability to test stationarity when structural breaks are present. More specifically, the ADF unit root test may confuse structural breaks in the data as proof of non-stationarity meaning that it fails to reject the unit root hypothesis. Meaning that data might be incorrectly categorized as I(1) although being stationary around a structural break, therefore, this paper employs the Zivot-Andrews (ZA) structural break unit root test by Zivot and Andrews (2002).

4.2.2 F-bounds Test and Error Correction Model

The first step in the ARDL model testing procedure is to conduct the bounds test. Applying the results from Eq.6 one can through an F-test establish whether a long-run relationship, in other words, whether cointegration exists among the variables. The hypothesis is as follows:

$$H_0 = \text{No cointegration } (\gamma_i = 0, \text{ where } i=1, \ldots, 7)$$

$$H_1 = \text{Cointegration } (\gamma_i \neq 0, \text{ where } i=1, \ldots, 7)$$

The F-test employed does not adhere to the normal distribution; rather, it requires two sets of critical values as proposed by Pesaran, Shin, and Smith (2001). One set of critical values suggests that all variables are I(0), whereas the other set assumes that the variables are I(1). One the one hand, when the estimated F-statistic exceeds the upper critical value, the null hypothesis of cointegration, can be rejected. On the other hand, if the F-statistic falls below the lower critical bound one cannot reject the null hypothesis of no cointegration. While an F-statistic that falls in the middle of the bounds is said to be inconclusive. However, Pesaran, Shin, and Smith (2001) constructed critical values applicable to larger samples. This study, therefore, adopts critical values proposed by Narayan (2005) for the F-test, since these are more suitable for smaller sample sizes.

When cointegration exists, Eq.6 is estimated employing a suitable lag length, based on either the Akaike information criteria (AIC) or Schwarz Bayesian criterion (SBC). However, the SBC is notorious for appointing the smallest possible lag length, hence being parsimonious. According to Lütkepol (2006), the attributes of the AIC is superior in comparison to the SBC since it supplies effective and reliable results and allows one to obtain the dynamic relationship among the variables.

Furthermore, when cointegration is confirmed, one can run the general error correction model (ECM). The ECM of Eq.6 is specified as follows:

$$\Delta lnCO_{2_t} = \delta_0 + \sum_{k=1}^{n1} \delta_{1k}\, \Delta lnCO_{2_{t-k}} + \sum_{k=0}^{n2} \delta_{2k} \Delta lnGDP_{t-k} + \sum_{k=0}^{n3} \delta_{3k}\, \Delta lnGDP_{t-k}^2 + \sum_{k=0}^{n4} \delta_{4k}\, \Delta lnEC_{t-k} + \sum_{k=0}^{n5} \delta_{5k} \Delta lnURB_{t-k} + \sum_{K=0}^{n6} \delta_{6k} lnTR_{t-k} + \sum_{K=0}^{n7} \delta_{7k} \Delta lnFD_{t-k} + \tau ECT_{t-1} + u_t$$

(Equation 7)

The τ indicates the speed of adjustment required for variables to adjust to long-run levels after a short-term shock. Furthermore, ECT_{t-1} depicts the residuals collected from the estimated long-run relationship model of Eq.4.

4.2.3 Diagnostic Testing and Robustness Checks

To reinforce the results and to test their robustness, this paper carries out several tests. To evaluate if serial correlation is present, this study adopts the Breusch-Godfrey test (Godfrey, 1978). While serial correlation does not influence the unbiasedness of the estimators it instead, has determinantal effects on the efficiency. The hypotheses are as follows:

H_0 = No serial correlation

H_1 = Serial correlation

Furthermore, to confirm that the residuals are homoscedastic (constant variance), this study adopts the Breusch-Pagan-Godfrey test (Breusch & Pagan, 1979; Godfrey, 1978). The ARDL model proposed above assumes that residuals are homoscedastic; however, if residuals turn out to be heteroscedastic (non-constant variance), estimated coefficients will no longer be unbiased. The hypotheses are as follows:

H_0 = No heteroscedasticity (homoscedasticity)

H_1 = Heteroscedasticity

Moreover, to assess whether the residuals are normally distributed, this paper utilizes the Jarque-Bera test (Jarque & Bera, 1987). Indications of non-normally distributed residuals may result in problems regarding statistical inferences of coefficient estimates that rely on the assumption of normality, for instance, the significance tests as well as confidence intervals (Gujarati & Porter, 2009). The hypotheses are as follows:

H_0 = The residuals are normally distributed

H_1 = The residuals are non-normally distributed

This study also employs the Ramsey Regression Specification Error Test (RESET) to assess whether the model is subject for misspecification (Ramsey, 1969). Misspecification results in biased and inconsistent estimators. The hypothesis is as follows:

H_0 = No misspecification

H_1 = Misspecification

Lastly, this study evaluates the stability of both the long-run and the short-run coefficients. One such approach is the cumulative sum of the recursive residuals (CUSUM) and the cumulative sum of squared recursive residuals (CUSUMSQ) deriving from Brown, Durbin, and Evans (1975). The tests are regularly employed using graphical representation in which one checks whether residuals do or do not significantly deviate from their average value by imposing parallel critical bounds at the 5% significance level. If the CUSUM and CUSMSQ statistics falls inside the critical bounds of 5% significance, the short-run and the long-run coefficients are assumed to be stable.

4.2.4 Error Correction-based Granger Causality

While the ARDL model determines whether cointegration prevails among the variables or not, it does not signal the direction of causality. The Granger representation theorem states that given an integration order of one, if cointegration exists, Granger causality should occur in at least one direction. However, assessing Granger causality through a vector autoregression while variables are in their first difference, might yield misleading results when cointegration is present (Engle & Granger, 1987). Therefore, one needs to adjust the VAR system by introducing an error correction term (ECT) that accounts for the long-run relationship. This modified VAR is a form of an augmented Granger causality test including an ECT and is, therefore, specified as a VECM, as follows:

$$\begin{bmatrix} \Delta lnCO_{2t} \\ \Delta lnGDP_t \\ \Delta lnGDP_t^2 \\ \Delta lnEC_t \\ \Delta lnURB_t \\ \Delta lnTR_t \\ \Delta lnFD_t \end{bmatrix} = \begin{bmatrix} \phi_1 \\ \phi_2 \\ \phi_3 \\ \phi_4 \\ \phi_5 \\ \phi_6 \\ \phi_7 \end{bmatrix} + \sum_{k=1}^{m} \begin{bmatrix} \theta_{1,1,k} & \theta_{1,2,k} & \theta_{1,3,k} & \theta_{1,4,k} & \theta_{1,5,k} & \theta_{1,6,k} & \theta_{1,7,k} \\ \theta_{2,1,k} & \theta_{2,2,k} & \theta_{2,3,k} & \theta_{2,4,k} & \theta_{2,5,k} & \theta_{2,6,k} & \theta_{2,7,k} \\ \theta_{3,1,k} & \theta_{3,2,k} & \theta_{3,3k} & \theta_{3,4,k} & \theta_{3,5,k} & \theta_{3,6,k} & \theta_{3,7,k} \\ \theta_{4,1,k} & \theta_{4,2,k} & \theta_{4,3,k} & \theta_{4,4,k} & \theta_{4,5,k} & \theta_{4,6,k} & \theta_{4,7,k} \\ \theta_{5,1,k} & \theta_{5,2,k} & \theta_{5,3,k} & \theta_{5,4,k} & \theta_{5,5,k} & \theta_{5,6,k} & \theta_{5,7,k} \\ \theta_{6,1,k} & \theta_{6,2,k} & \theta_{6,3,k} & \theta_{6,4,k} & \theta_{6,5,k} & \theta_{6,6,k} & \theta_{6,7,k} \\ \theta_{7,1,k} & \theta_{7,2,k} & \theta_{7,3,k} & \theta_{7,4,k} & \theta_{7,5,k} & \theta_{7,6,k} & \theta_{7,7,k} \end{bmatrix}$$

$$* \begin{bmatrix} \Delta lnCO_{2t-k} \\ \Delta lnGDP_{t-k} \\ \Delta lnGDP_{t-k}^2 \\ \Delta lnEC_{t-k} \\ \Delta lnURB_{t-k} \\ \Delta lnTR_{t-k} \\ \Delta lnFD_{t-k} \end{bmatrix} + \begin{bmatrix} \lambda_1 \\ \lambda_2 \\ \lambda_3 \\ \lambda_4 \\ \lambda_5 \\ \lambda_6 \\ \lambda_7 \end{bmatrix} * ECT_{t-1} + \begin{bmatrix} \mu_{1,t} \\ \mu_{2,t} \\ \mu_{3,t} \\ \mu_{4,t} \\ \mu_{5,t} \\ \mu_{6,t} \\ \mu_{7,t} \end{bmatrix}$$

(Equation 8)

Where ϕ_j (j = 1,…,7) indicates a time-invariant constant, k (k = 1,…, m) represents the optimal lag length as proposed by AIC. Furthermore, one can attain ECT_{t-1} from the lagged residual of the long-run relationship presented in Eq.4. Moreover, λ_j (j = 1,…,7) symbolizes the adjustment coefficients, and lastly, $\mu_{j,t}$ (j = 1,…,7) resembles the disturbance term. Unlike Eq.4, in which each regressor may have different lag structures, all error-correction vectors in Eq.8 are estimated utilizing the same lag structure, estimated by AIC.

The error correction-based Granger causality investigation captures both short-run as well as long-run causal links. By employing the Wald statistics of the lagged explanatory variables, one can obtain the short-run causality, whereas, the Wald statistics of the lagged ECT identifies the long-run causality.

However, the VECM Granger causality test experiences some shortcomings. As is stressed by Shahbaz, Hye, Tiwari, and Leitão (2013) as well as Salahuddin, Gow, and Ozturk (2015) the accuracy of the analysis may deplete due to the failure of the test of capturing the relative strength of the causality among the variables beyond the period under study. Furthermore, the VECM only indicates the direction of the causality and not its sign and magnitude. Therefore, to deal with these limitations, this paper, like Shahbaz, Hye, Tiwari, and Leitão (2013) as well as Salahuddin, Gow, and Ozturk (2015) employs an IAA which consists of a generalized impulse response functions as well as a variance decomposition method.

4.2.5 Innovative Accounting Approach

To review the strength of the causality, this study conducts a variance decomposition and a generalized impulse response function, as proposed by Koop, Pesaran and, Potter (1996) as well as Pesaran and Shin (1998). The main advantage of the generalized impulse function is that it is indifferent to the ordering of the variables in the VECM (Soytas, Sari and Ewing, 2007). The generalized impulse response function illustrates how one variable answers to a shock in a different variable and whether this reaction dies out quickly or persists. However, it does not portray the magnitudes of these effects. Therefore, this study applies a variance decomposition method since it depicts the percentage of a variable´s forecasted error variance when accounting for shocks in other variables. Similarly, to the impulse response function, it may be utilized over various time-horizons as well as beyond the selected period.

5 Results and Analysis

5.1 Unit Root Test

This paper implements the ARDL bounds testing approach to study the long-run relationship between CO_2 emissions, economic growth, energy consumption, urbanization, trade, and financial development in the case of Canada. If a series is stationary at I(2) or of a higher order of integration, the derived ARDL F-statistic is no longer appropriate. Therefore, to determine the order of integration, this study employs the ADF unit root test as well as the ZA unit root test. Observed in Table 5.1 are the results of these unit root tests.

Table 5.1 Results of Unit Root Tests

Unit Root Test							
	CO_2	GDP	GDP^2	EC	URB	TR	FD
ADF-test							
Level	-2.1163	-2.8759	-2.2670	-2.9081	-5.1907[a]	-1.9630	-1.9090
Δ	-6.8507[a]	-5.6545[a]	-6.4044[a]	-5.1101[a]	-	-5.3028[a]	-7.7895[a]
ZA-test							
Level	-3.7700	-3.4800	-7.8727[a]	-3.7545	-4.9711[a]	-4.6553	-3.6906
	(1969)	(1974)	(1986)	(1973)		(1995)	(1976)
Δ	-8.0841[a]	-6.7392[a]	-	-7.0192[a]	-	-6.2851[a]	-8.1981[a]
	(1986)	(1991)		(1982)		(2000)	(1966)
Decision	I(1)	I(1)	I(0)	I(1)	I(0)	I(1)	I(1)

Δ symbolizes first difference. Years in the parenthesis are structural break dates.
Lag lengths are selected based on Akaike information criterion (AIC)
a Statistical significance at 1% levels
b Statistical significance at 5% levels
c Statistical significance at 10% levels

The empirical evidence of the ADF unit root test suggests that while urbanization is stationary at I(0), CO_2 emissions, GDP, GDP^2, energy consumption, trade, and financial development are I(1). To validate the findings of the ADF unit root test, this study proceeds with a ZA structural break unit root test. According to this assessment, both urbanization and GDP^2, are stationary in their levels, whereas, all other variables are stationary in their first differences. Both tests draw similar conclusions in all instances except for GDP^2; however, the order of integration does not exceed I(1), therefore, it is safe to proceed with the ARDL bounds testing approach to cointegration.

5.2 ARDL Approach to Cointegration

Given that all variables have an integration order below two and that AIC determines the optimal lag length, the next phase is to adopt the F-test to determine whether variables are cointegrated, this is done by estimating Eq.6. Table 5.2 communicates the empirical evidence for the F-test and the upper and lower critical value bounds at both a 1% level as well as at a 5% level. The empirical results show that the estimated F-statistic exceeds the upper critical values when CO_2 emissions are the response variable and GDP, GDP^2, energy consumption, urbanization, trade, and financial development are explanatory variables. Therefore, one can reject the null hypothesis of no cointegration and confirm that the variables have a long-run relationship at a 1% significance level.

However, it could be the case that energy consumption explains most of this relationship to CO_2 emissions. When excluding energy consumption from the model, to control for this possibility, the derived F-statistic still exceeds the upper critical bound, this time at a 5% significance level. To sum up, all variables, excluding energy consumption, are cointegrated with CO_2 emissions at a 5% significance level. Thus, the inclusion of energy consumption in the model does not drive the long-run relationship. Therefore, energy consumption is accounted for in all testing moving forward.

Table 5.2 The ARDL Approach to Cointegration

Cointegration Testing					
Estimated Model	F-statistic	5% Critical Values		1% Critical Values	
		I(0)	I(1)	I(0)	I(1)
$f(CO_2/GDP, GDP^2, EC, URB, TR, FD)$	5.9753[a]	2.791	3.950	3.643	5.021
$f(CO_2/GDP, GDP^2, URB, TR, FD)$	4.7257[b]				

Critical values comes from Narayan (2005), p. 1989, Case IV

a Statistical significance at 1% levels

b Statistical significance at 5% levels

c Statistical significance at 10% levels

5.3 Short-run and Long-run Estimates

After verifying that a long-run relationship prevails among the variables, the next stage is to analyze the marginal impacts of the individual variables on CO_2 emissions. Reported in Table 5.3 are the estimated coefficients. The long-run results suggest that energy consumption is the main contributor to CO_2 emissions, followed by economic growth and trade in the case of Canada. More precisely, the results imply that ceteris paribus, a % increase in energy consumption increases CO_2 emissions with approximately 1.02%. A similar conclusion applies to the short-run estimate. These results comparable to findings in other studies, for instance, Ang (2007, 2009), Halicioglu (2009), Jalil and Feridun (2011), Ozturk and Acaravci (2013), Shahbaz, Tiwari and Nasir (2013) Shahbaz, Hye, Tiwari and Leitão (2013), Farhani and Ozturk (2015), Al-Mulali Saboori and Ozturk (2015), Al-Mulali Tang and Ozturk 2015) as well as Dogan and Turkekul (2016).

Similarly, one can confirm a positive and statistically significant relationship between economic growth and CO_2 in the long-run. Therefore, a 1% increase in economic growth is related to a 0.28% rise in CO_2 emissions, ceteris paribus. Furthermore, a 1% rise in GDP^2 is associated with a 0.01% rise in CO_2 emissions, ceteris paribus. Accordingly, the elasticity of CO_2 emissions with respect to real GDP in the long-run can be specified as 1.0203+0.028Y. The elasticity implies that CO_2 emissions continue to expand without arriving at some turning point of real GDP when real income grows. These findings contradict the EKC hypothesis in which the coefficient of GDP is predicted to be positive, and GDP^2 is expected to be negative.

Therefore, the empirical evidence does not reinforce the presence of the EKC hypothesis in the case of Canada. Moreover, Figure 5.1 portrays the relationship between CO_2 emissions per capita and real GDP per capita, and while the curve fluctuates, there is no significant downward trend, hence no clear EKC. Turning to the short-run, GDP is insignificant, and GDP^2 portrays a positive and significant relationship with CO_2 emissions in the current period. The findings are consistent with various studies that have failed to confirm the existence of the EKC, for instance, Dogan and Turkekul (2016), Al-Mulali, Saboori and Ozturk (2015), and Baek (2015). Similarly, He and Richard (2010) find no evidence of the EKC for Canada; instead, they support the suggestion of a monotonic increasing curve with a slope changing over time.

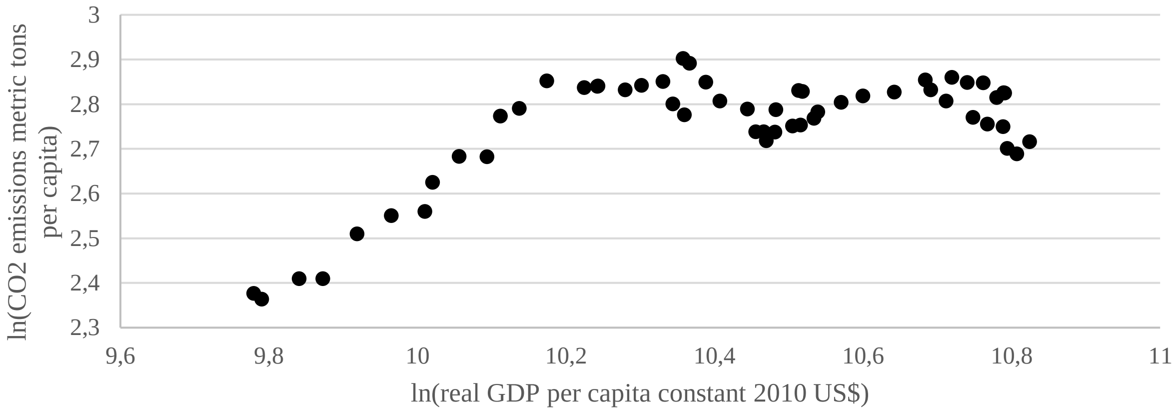

Figure 5.1 Plot of EKC for Canada, 1960-2014.

(Source: The World Bank, 2019a, 2019c)

Similarly, trade is positively connected to CO_2 emissions and is statistically significant at the 10% significance level. More precisely in the long-run, a 1% increase in trade results in CO_2 emissions expanding by 0.10%. On the other hand, the short-run elasticity estimate of CO_2 emissions with respect to trade is not statistically significant in the current period. The positive coefficient of trade in the long-run conforms with findings in studies such as Grossman and Krueger (1995), Ang (2009), among others. These findings indicate that trade openness has a negative meaning for the environment.

Regarding financial development and urbanization, the empirical results indicate that these variables do not significantly influence CO_2 emissions in the long-run. However, in the short-run, the two statistically negatively affect CO_2 emissions in the current period. The findings of an insignificant impact of urbanization contradict studies such as Hossain (2011), Farhani and Ozturk (2015), Dogan and Turkekul (2016), among others. Whereas, the evidence of a statistically insignificant impact of financial development, on the other hand, is in line with studies such as Ozturk and Acaravci (2013) and Dogan and Turkekul (2016) for instance.

Table 5.3 Estimated Coefficients from ARDL Model

Coefficients from ARDL model			
Regressors	Coefficient	T-statistic	
(A) Long-run estimates (dependent variable CO_2)			
GDP	0.2803[b]	2.0591	
GDP^2	0.0140[a]	5.4582	
EC	1.0203[a]	6.9983	
URB	0.2721	0.4811	
TR	0.1026[c]	1.8643	
FD	-0.0110	-0.5945	
Constant	-8.7724[a]	-3.1776	
(B) Short-run estimates (dependent variable ΔCO_2)			
ΔCO_{2t-1}	-0.0386	-0.5610	
$\Delta CO2_{t-2}$	-0.1585[b]	-2.5108	
ΔGDP	-0.1142	-0.9082	
ΔGDP^2	0.0055[a]	5.1099	
ΔGDP^2_{t-1}	-0.0044[a]	-3.0145	
ΔGDP^2_{t-2}	-0.0032[b]	-2.6104	
ΔGDP^2_{t-3}	-0.0036[a]	-2.8809	
ΔEC	0.9553[a]	8.6066	
ΔURB	-1.9258	-1.2552	
ΔURB_{t-1}	3.7109[b]	2.3550	
ΔTR	0.0400	0.9009	
ΔTR_{t-1}	-0.0862[b]	-2.1221	
ΔTR_{t-2}	-0.0877[b]	-2.2781	
ΔFD	-0.0347[b]	-2.3279	
ΔFD_{t-1}	-0.0396[a]	-2.8015	
ΔFD_{t-2}	-0.0244	-1.5517	
ΔFD_{t-3}	-0.0469[a]	-3.0102	
Constant	-8.7824[a]	-7.8301	
ECT_{t-1}	-0.8259[a]	-7.8223	
Diagnostic tests			Prob.
Serial correlation			(0.3296)
Functional Form			(0.6650)
Normality			(0.3386)
Heteroscedasticity			(0.9415)
R^2			0.9436
F-statistic			29.741

The values in parenthesis under diagnostic tests are the p-values.
The proper lag length of the estimated ARDL model is (3, 1, 4, 2, 3, 4, 1) and is based on AIC.

a Statistical significance at 1% levels
b Statistical significance at 5% levels
c Statistical significance at 10% levels

According to Baek (2015), the ECT_{t-1} in Table 5.3 can also indicate whether the variables are cointegrated or not. More precisely, cointegration prevails if the estimated coefficient is negative and statistically significant. Similarly, to the ARDL bounds testing approach to cointegration, the ECT_{t-1} claim that there is a long-run relationship between CO_2 emissions, GDP, GDP^2, trade, urbanization, and financial development since the estimate is -0.8259 and statistically significant at a 1% level. The magnitude of this coefficient proposes that approximately 83% of any short-run disequilibrium (to the long-run equilibrium) between CO_2 and all other variables is corrected within one year. Hence, any short-run shock to the environmental function is adjusted vastly and rapidly

Furthermore, this study conducted and passed numerous diagnostic checks, seen in Table 5.3. Since all p-values of the various tests exceed the 10% significance level, one can reject each of the null hypothesis for the various diagnostic tests. The empirical findings, from the CUSUM and CUSUMSQ, is observed in Figure 5.2, suggest that the estimated coefficients are stable. A stable environmental function is a pre-requisite for drawing policy implications (Halicioglu, 2009; Shahbaz, 2013; Farhani, Shahbaz, Arouri & Teulon, 2014).

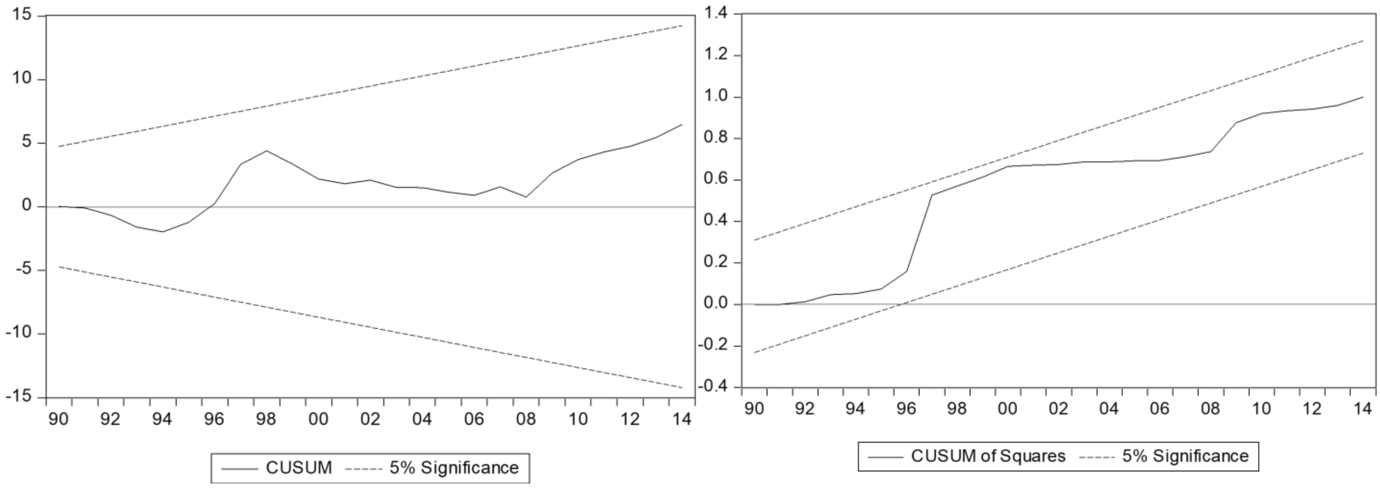

Figure 5.2 Plots of CUSM and CUSUMSQ of Recursive Residuals

5.4 Granger Causality Test Results

Previous evidence suggests that cointegration exists among CO_2 emissions and all other variables the next step, therefore, is to perform a VECM Granger causality test to determine the long-run as well as short-run causality among the variables. Awareness of the causal interconnections among the variables is of significance for policy-making authorities since it may aid in determining appropriate policies allowing the economy to sustain economic growth and advance the environmental health throughout time. Table 5.4 indicates the casual links derived from the Granger causality test. In the long-run all variables experience long-run causal relationships with each other, one exception being with GDP^2. Moving forward, this study focuses only on the causal relations of interest.

Table 5.4 Granger Causality Test Results

Causality Analysis								
Dependent Variable	Short-run analysis							Long-run analysis
	ΔCO_2	ΔGDP	ΔGDP^2	ΔEC	ΔURB	ΔTR	ΔFD	ECT_{t-1}
ΔCO_2	-	0.0000	1.0691	4.7553[a]	0.0528	0.5738	4.9778[b]	22.0576[a]
ΔGDP	0.1379	-	1.9438	2.7828[c]	0.5997	2.2407	0.0000	16.4067[a]
ΔGDP^2	0.0003	0.0294	-	0.0055	0.0486	0.0039	0.0146	0.8019
ΔEC	3.2218[c]	3.3271[c]	0.1290	-	1.9142	0.4709	4.1729[b]	34.1188[a]
ΔURB	0.8662	3.8027[c]	1.3751	1.7057	-	1.5785	2.9609[c]	13.6339[a]
ΔTR	1.2386	1.1093	1.8912	1.8912	2.0252	-	0.1231	18.8144[a]
ΔFD	0.5480	0.7097	0.2940	2.3845	1.2697	0.0093	-	10.6485[a]

Values are from Wald test based on the chi-square distribution
a Statistical significance at 1% levels
b Statistical significance at 5% levels
c Statistical significance at 10% levels

The empirical results suggest that energy consumption and CO_2 emissions, energy consumption and economic growth, as well as economic growth and CO_2 emissions, portrays bidirectional causal links. Hence, the feedback hypothesis is present in all of these cases. In other words, these results imply that CO_2 and energy consumption, as well as economic growth, are interdependent. These connections are related to the considerable share of fossil fuels in the energy mix. However, the evidence does not confirm a causal link between GDP^2 and CO_2 emissions, thus, supporting previous results that do not verify the EKC. These findings imply that waiting for the turning point of CO_2 emissions deriving from increased economic growth, as suggested by the EKC hypothesis, will not be a sustainable path for Canada´s battle against climate change.

Instead, since CO_2 emissions, energy consumption, and economic growth are interdependent, the Canadian economy cannot lower energy consumption and CO_2 emission for the sake of environmental quality since this might constrain economic growth. In short, conservation of energy implies less activity. The results, therefore, suggest that with the current setup, the Canadian economy will struggle to decouple GDP from CO_2 emissions. One should, therefore, aspire to improve efficiency since this would allow domestic production to advance while less energy is used and less being emitted.

In other words, there is an urgency for policy reforms raising incentives for an overhauling of the energy system towards the adoption of more energy efficient technologies or cleaner ones. Canada possesses adequate sources of renewable energy, such as wind, which would allow them to both meet the energy demand as well as deal with the environmental issues posed by CO_2 emissions. Moreover, policy recommendations will primarily affect electricity since it stands for a considerable share of energy-related CO_2 emissions. Similarly, transportation constitutes a fair share of energy-related CO_2 emissions. Therefore, policy-making authorities should enlarge the incentives for investments in environmental-friendly vehicles. Thus, this study suggests that Canada has not fully exploited these alternative energy sources since energy consumption significantly impacts CO_2 emissions and while the emission-efficiency seem to progress throughout time due to the technological effect, one cannot so far observe a clear falling trend in CO_2 emissions in the case of Canada.

The results, moreover, indicates a bidirectional causal relationship between financial development and CO_2 emissions. Hence, the variables are complimentary. A probable justification for this relation is that financial development, as mentioned above, may influence CO_2 emissions and energy consumption both positively and negatively, and at the same time, CO_2 emissions and/or energy consumption may enhance incentives for the financial sector to embark on innovations that may mitigate emissions.

Supported by the IAA in the next section, these findings confirm the suggestion that financial development causes CO_2 emissions to expand. Hence, increased investments and consequently, consumption causes energy use and, therefore, CO_2 emissions to rise. In other words, investments have not been in more advanced and energy efficient technologies, which is required for the energy efficiency to improve, hence explaining its slow progression. The bidirectional causality between energy consumption and financial development further support these findings. Moreover, the supply-side hypothesis is verified as financial development Granger causes economic growth and trade openness.

However, these findings suggest that policy-making authorities have much potential to work with. With the right policies, financial development could play a significant role in abating energy consumption and CO_2 emissions. Hence, policy-making authorities should account for financial development when determining policies by, for instance, enhancing the institutional framework since this would expand firms´ motivation to take steps in an environmentally friendly direction. Another possible approach is to raise incentives and financial support to institutions, universities, as well as research and development, to increase research programs focusing on evolving modern and energy efficient technologies lowering emissions. Therefore, it is vital to have a proper financial sector such that the loans necessary can be obtained; this will not only alter the focus of investments but also change consumption patterns. In short, by further improving financial development, Canada could reach its targets and national objectives to lower environmental degradation.

Similarly, bidirectional causality between trade and CO_2 emission exists. According to trade theory, a country should specialize according to its comparative advantage this, therefore, has significant implications for a country´s impact on the environment. Canada, with its natural resources, has a clear comparative advantage in producing and exporting goods such as forest products, natural gas, and petroleum. Canada will, therefore, bear the cost of the emissions created throughout the production process. Furthermore, it seems that trade openness contributes to a long-run increase in pollution-intensive activities and higher CO_2 emissions, in other words, the enhanced market deriving from trade results in, depletion of natural resources, which consequently expands CO_2 emissions and negatively influences the environmental health.

Thus, the scale effect that derives from trade liberalization and negatively influences the environment offsets possible positive effects evolving from the technique effect and/or composition effects. It implies that production techniques, yet, have not changed in such a fashion that the positive effects created by the technique effect and/or composition effects outweighs the scale effect. Efforts should, therefore, be on stimulating advancements in technology such that efficiency and emissions levels enhance, which is made possible through financial development.

Furthermore, urbanization and CO_2 emission portray a bidirectional causal relationship, unlike the long-run results from the ARDL in which urbanization was insignificant. A probable argument for this is that urbanization can impact CO_2 emissions and energy consumption, both positively and negatively. However, CO_2 and energy consumption may boost environmental awareness and economies of scale and consequently, lower emissions. However, according to the IAA, it has an expanding effect on CO_2, thus implying that the urban inhabitants cannot harmonize increasing material well-being with a lower environmental impact.

When urbanization has expanding effects on energy consumption and/or CO_2 emissions, it may be beneficial to halt urbanization. However, another viable possibility is to cut down energy consumption in urban areas by, for instance, targeting the urban transportation networks such that one economizes the transportation. Moreover, going hand in hand with financial development, one should support innovative activities that may restrict future increases in energy consumption and CO_2 emissions. Ultimately cities should be converted into low-carbon cities which are accomplished by improving energy efficiencies, lowering CO_2 intensities as well as controlling transportation demands moving forward.

In the short-run, the Granger causality test suggests that there exists a bidirectional interconnection between CO_2 emissions and energy consumption as well as between energy consumption and economic growth. Thus, the feedback hypothesis is present in the short-run too. Furthermore, four unidirectional relationships are established, running from financial development to CO_2, emissions, and from financial development to energy consumption as well as from financial development to urbanization. Lastly, GDP Granger causes urbanization.

5.5 Innovative Accounting Approach

This study applies an IAA by considering a generalized impulse response functions as well as a variance decomposition method to depict the interactive relationships between the variables, hence giving a more profound understanding of the previously conducted Granger causality test. The findings are mainly in line with previous results and will be discussed more in detail below. Table 5.5 reports the results of the variance decomposition, and Figure 5.3 indicates the results for the impulse response function.

The empirical evidence indicates that a portion of 30% originates from an innovative shock in CO_2 emissions itself. Furthermore, one standard deviation shock both in energy consumption and economic growth impacts CO_2 emissions by approximately 3%. Furthermore, the share of urbanization, trade, and financial development is more considerable, 17%, 16%, and 39% respectively. Turning to energy consumption, CO_2 emissions, economic growth, urbanization, trade, and financial development contributes 6%, 9%, 4%, 6%, and 38% respectively. Hence the remaining fraction is related to innovative shocks of energy consumption itself. Furthermore, an innovative shock in economic growth explains 51% of itself. One standard deviation shock in CO_2 emissions affects economic growth by 18% and energy consumptions share to economic growth is 2 %. Economic growth is mainly unchanged by one standard deviation shock deriving in urbanization, reacts 2% from a shock stemming in trade, and 25% due to a shock in financial development.

Furthermore, urbanization remains rather unaffected by one standard deviation shock in CO_2 emissions and financial development, whereas 5% derives from an innovative shock in energy consumption. An innovative shock in urbanization itself explains 35%. One standard deviation shock deriving from economic growth and trade attribute to urbanization by 46%, 13%, respectively. Furthermore, an innovative shock in CO_2 emissions, energy consumption, and economic growth explains trade by 7%, 18%, and 12% respectively. Moreover, the share of urbanization and financial development that contribute to trade is 10% and 29% while an innovative shock in itself stands for a portion of 24%. Lastly, the contribution of CO_2 emissions, economic growth, energy consumption, urbanization, and trade to financial development is 19%, 15%, 1%, 1%, and 10% respectively. Whereas, one standard shock of financial development itself explains the rest.

Table 5.5 Variance Decomposition Approach

Variance decomposition approach															
Period	**S.E.**	$lnCO_2$	lnGDP	lnEC	lnURB	lnTR	lnFD	**Period**	**S.E.**	$lnCO_2$	lnGDP	lnEC	lnURB	lnTR	lnFD
Variance Decomposition of $lnCO_2$:								*Variance Decomposition of lnURB:*							
1	0.0274	100.0000	0.0000	0.0000	0.0000	0.0000	0.0000	1	0.0011	0.8252	7.0095	6.5179	85.6475	0.0000	0.0000
2	0.0324	95.7838	2.9185	0.0055	0.4917	0.7992	0.0013	2	0.0022	0.4354	13.9153	4.6944	79.5943	0.6239	0.7367
3	0.0359	81.6519	5.2454	1.1784	2.0161	1.6890	8.2193	3	0.0033	0.6502	19.5172	5.2817	71.5234	2.5974	0.4301
4	0.0404	65.5110	5.2310	3.2588	4.4856	2.7713	18.7422	4	0.0045	0.9194	25.0217	5.3481	63.2938	5.1340	0.2831
5	0.0451	52.9991	4.8154	4.2839	7.4844	4.5133	25.9040	5	0.0058	0.8870	30.0030	5.3127	55.9739	7.4759	0.3475
6	0.0501	43.1069	4.1773	4.6301	10.4114	6.6699	31.0043	6	0.0072	0.7408	34.2248	5.3359	49.9080	9.3678	0.4228
7	0.0554	35.5229	3.4528	4.5825	12.9083	9.0172	34.5164	7	0.0086	0.5932	37.7969	5.3808	44.9772	10.7736	0.4784
8	0.0608	29.6996	2.8913	4.2916	14.8824	11.4718	36.7633	8	0.0100	0.4731	40.8467	5.4190	40.9901	11.7594	0.5117
9	0.0664	25.1323	2.6495	3.8956	16.3476	13.8800	38.0951	9	0.0114	0.3822	43.4444	5.4467	37.7816	12.4203	0.5248
10	0.0721	21.5269	2.7794	3.4811	17.3810	16.0952	38.7364	10	0.0127	0.3149	45.6468	5.4649	35.2097	12.8411	0.5227
Variance Decomposition of lnGDP:								*Variance Decomposition of lnTR:*							
1	0.0179	22.8665	77.1335	0.0000	0.0000	0.0000	0.0000	1	0.0399	16.5520	20.6606	2.5623	3.7101	56.5150	0.0000
2	0.0281	29.6992	66.9684	0.9492	0.2918	0.6682	1.4233	2	0.0583	18.4438	15.4108	9.2377	5.4636	47.5495	3.8945
3	0.0344	28.2475	64.7413	1.2827	0.6749	0.5805	4.4730	3	0.0719	14.0550	10.2255	14.3220	6.3043	42.7353	12.3580
4	0.0393	24.2741	63.1176	1.7151	0.7804	0.4655	9.6472	4	0.0881	9.7338	9.2129	16.1848	6.7054	37.4848	20.6783
5	0.0436	21.4521	60.8911	2.1531	0.7147	0.5309	14.2580	5	0.1060	8.3491	9.6498	16.7378	7.1881	32.7041	25.3711
6	0.0474	19.9777	58.9377	2.3768	0.6230	0.7277	17.3572	6	0.1219	7.7523	10.3508	17.1122	7.9051	29.6925	27.1873
7	0.0509	19.1685	57.0936	2.4461	0.5451	1.0293	19.7175	7	0.1356	7.4170	10.9477	17.3683	8.6329	27.7968	27.8373
8	0.0540	18.6729	55.1514	2.4510	0.4843	1.4189	21.8215	8	0.1479	7.2599	11.3971	17.5414	9.2292	26.4129	28.1595
9	0.0568	18.3742	53.1409	2.4245	0.4378	1.8785	23.7441	9	0.1593	7.2049	11.7343	17.6734	9.6882	25.3209	28.3784
10	0.0594	18.2131	51.1463	2.3795	0.4024	2.3819	25.4768	10	0.1701	7.1986	11.9816	17.7833	10.0493	24.4503	28.5369
Variance Decomposition of lnEC:								*Variance Decomposition of lnFD:*							
1	0.0182	41.7870	11.3638	46.8492	0.0000	0.0000	0.0000	1	0.1092	0.4063	0.2164	0.0012	0.0343	5.0656	94.2761
2	0.0256	29.4202	21.8381	46.7451	0.0200	0.0007	1.9759	2	0.1412	3.2279	1.8740	1.7968	0.4440	7.0906	85.5667
3	0.0340	16.9210	21.3070	47.3902	0.0378	0.1012	14.2429	3	0.1657	10.9707	7.1904	1.4719	0.7625	7.4295	72.1750
4	0.0431	11.9593	17.7568	45.8966	0.2963	0.4199	23.6711	4	0.1891	15.1137	11.5345	1.2250	0.8487	7.3016	63.9766
5	0.0512	9.8497	15.6225	44.3695	0.8023	0.9561	28.4001	5	0.2110	16.8399	13.7375	1.0928	0.8641	7.3647	60.1011
6	0.0584	8.6219	14.1660	42.8748	1.4165	1.6494	31.2715	6	0.2315	17.5414	14.7882	1.0036	0.8947	7.7187	58.0535
7	0.0649	7.7557	12.8068	41.4432	2.0339	2.4862	33.4742	7	0.2508	17.9664	15.2582	0.9266	0.9516	8.2196	56.6777
8	0.0709	7.1042	11.4433	40.0316	2.6150	3.4705	35.3354	8	0.2691	18.3778	15.3579	0.8544	1.0218	8.7686	55.6195
9	0.0765	6.5867	10.1347	38.6370	3.1494	4.5664	36.9259	9	0.2862	18.7733	15.2044	0.7863	1.0939	9.3353	54.8069
10	0.0818	6.1511	8.9567	37.2921	3.6336	5.7129	38.2536	10	0.3025	19.1189	14.8838	0.7243	1.1630	9.9036	54.2064

According to the impulse response function, CO_2 emissions positively respond to one standard shock in energy consumption. Similarly, the reaction in CO_2 emissions is positive by a shock deriving in economic growth. However, the strong influence economic growth has on CO_2 emissions diminishes over time. Urbanization, trade, and financial development portray similar patterns, in which CO_2 emissions are positively affected by all of them. Hence, these variables enlarge CO_2 emissions. Therefore, they are significant factors in accounting for alternations in CO_2 emissions.

Energy consumptions first increase and after that becomes negative over time due to a shock in CO_2 emissions. The shape of the curve implies that CO_2 emissions drive the use of energy consumption; however, over time, this influence diminishes and even becomes negative. Moreover, economic growth, trade, and financial development positively contribute to energy consumption. On the other hand, the response of energy consumption is depleting first and then becomes positive due to an innovative shock in urbanization. Regarding economic growth, all variables except for urbanization positively contribute to economic growth. Instead, urbanization portrays a negative U-curve. The shock in CO_2 emissions increases economic growth, thus suggesting that escalating CO_2 emissions will boost economic growth, and the effect is not marginal.

A standard shock in CO_2 emissions, energy consumption, economic growth, and financial development reduces urbanization, whereas trade increases it. Trade, on the other hand, is first expanding and then becomes negative due to a standard shock in CO_2 emissions and economic growth. Whereas, energy consumption, urbanization, and financial development contributions to trade are growing. Lastly, a standard shock in CO_2 emissions, economic growth, and trade positively contributes to financial development, whereas urbanization negatively impacts it.

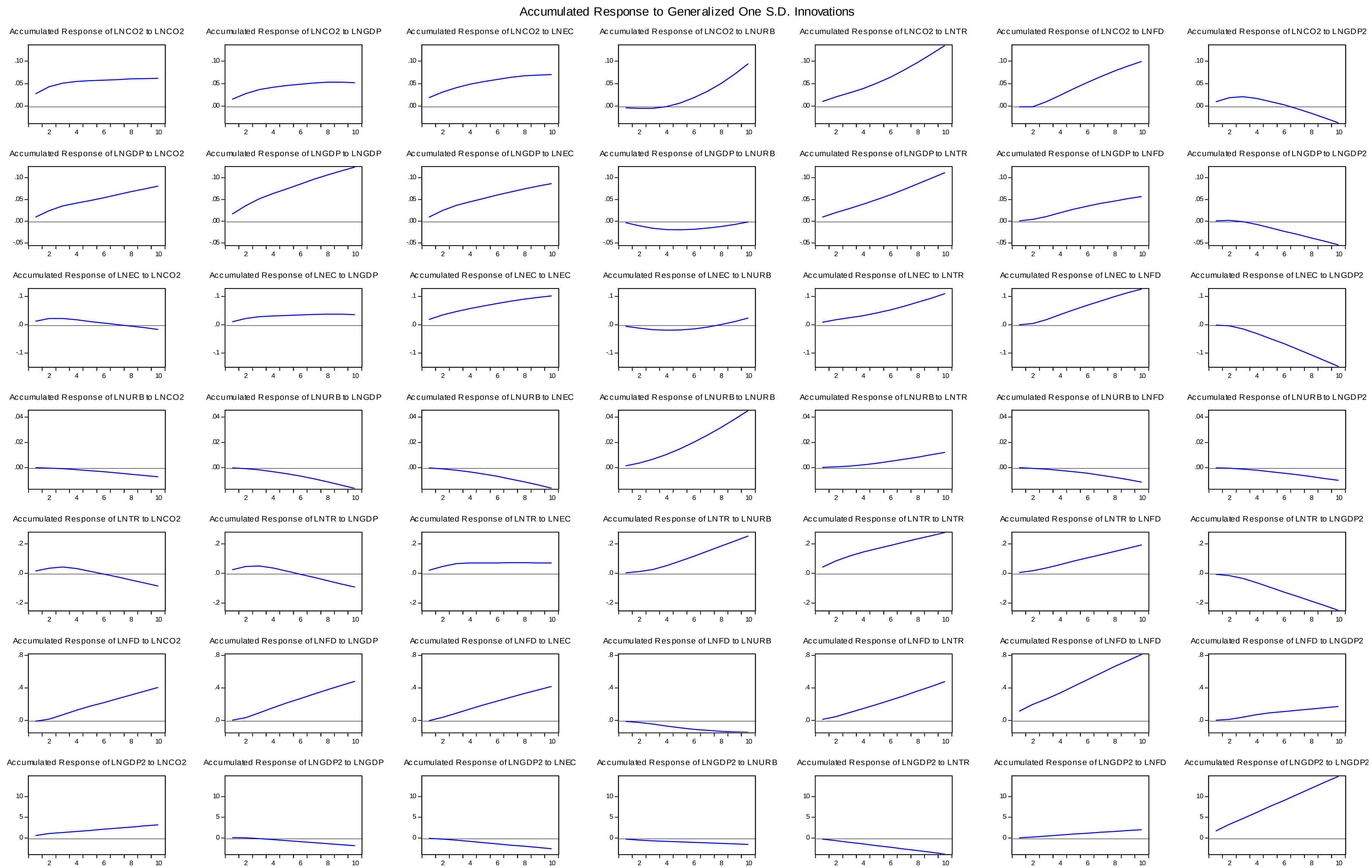

Figure 5.3 Generalized Impulse Response Function

6 Conclusion

One of the most urgent matters facing us today is environmental changes. The growing concerns of particularly CO_2 emissions and its burden on the globe have given rise to a vast number of studies. The studies generally focus on the relationship between energy consumption, economic growth, and CO_2 emissions; however, they might suffer from omitted variable bias. Therefore, more recent studies choose to account for various aspects of the economy, for instance, urbanization, trade, and financial development, when studying the environmental function.

Since financial development is more recently included, only a limited number of studies and empirical results exists regarding its impact on environmental performance. Therefore, this study aimed to investigate the dynamic relationship between CO_2 emissions, economic growth, energy consumption, urbanization, trade and financial development in the case of Canada, one of the largest CO_2 emitters both in per capita and in absolute terms, over the period 1960-2014. For this purpose, this study applied two different unit root tests, an ARDL bounds testing approach to cointegration, a Granger causality test based on a VECM and lastly an IAA.

The results demonstrate that none of the variables analyzed exceeds an integration order of one and that the variables are cointegrated. It is moreover concluded that GDP, GDP^2, energy consumption, and trade expands CO_2 emissions, in the long-run, whereas financial development and urbanization remain insignificant. The evidence, therefore, does not support the environmental Kuznets curve hypothesis since both GDP and GDP^2 positively relates to CO_2 levels. The causal analysis confirms that in the long-run, bidirectional causality is present between CO_2 emissions and energy consumption, CO_2 emissions and economic growth, as well as between economic growth and energy consumption. Moreover, the study confirms that urbanization, trade, and financial development all have a bidirectional causal link with CO_2 emissions.

The statistical findings of this study do not support the EKC hypothesis, although controlling for additional factors that may influence CO_2 emissions. These findings imply that economic growth is not the solution to Canadian CO_2 emissions. Instead, political intervention is necessary to maintain economic growth while simultaneously improving the environment. Since energy conservation policies will adversely impact economic growth, the Canadian economy should, in short, improve energy efficiency by the adoption of advanced technologies through either the financial sector or international trade.

Alternatively, Canada can meet its energy demand by adopting alternative energy sources, for instance, wind power. Furthermore, policy-making authorities should not only aim at enhancing the institutional framework increasing firms´ incentives to make progress in an environmentally friendly direction. Policy-making authorities should also, encourage and finance research programs focusing on evolving modern and energy efficient technologies and its adoption, whether developed domestically or abroad. Also, policy-making authorities should take actions towards low-carbon cities by for, instance, economize transportation.

To sum up, the continued upward trend of CO_2 emissions is a problematic issue for Canada. To expect economic growth to solve the environmental problems, as suggested by the EKC, is in the case of Canada not correct. Although emission-efficiency has improved, this has not yet made an immense impact on the trend of CO_2 emissions. To act against this debatable issue, there is an urgency for comprehensive economic, financial, trade, and energy policy reforms in order to sustain economic growth by evolving the domestic financial sector. In other words, financial support, targeted policies, and advanced technologies are critical to developing the Canadian economy and its energy sector sustainably.

However, one should not forget that this is a global issue. Therefore, one can extend this type of study for future research by taking on a more global approach looking at how the global GDP, energy consumption and CO_2 levels interact, or by considering other potential proxies for environmental degradation. One could also include other possible variables into the modified EKC framework that may impact CO_2 emissions, or one could focus on the relationship between renewable energy consumption and its relation to economic growth and CO_2 emissions in the case of Canada.

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Appendix A

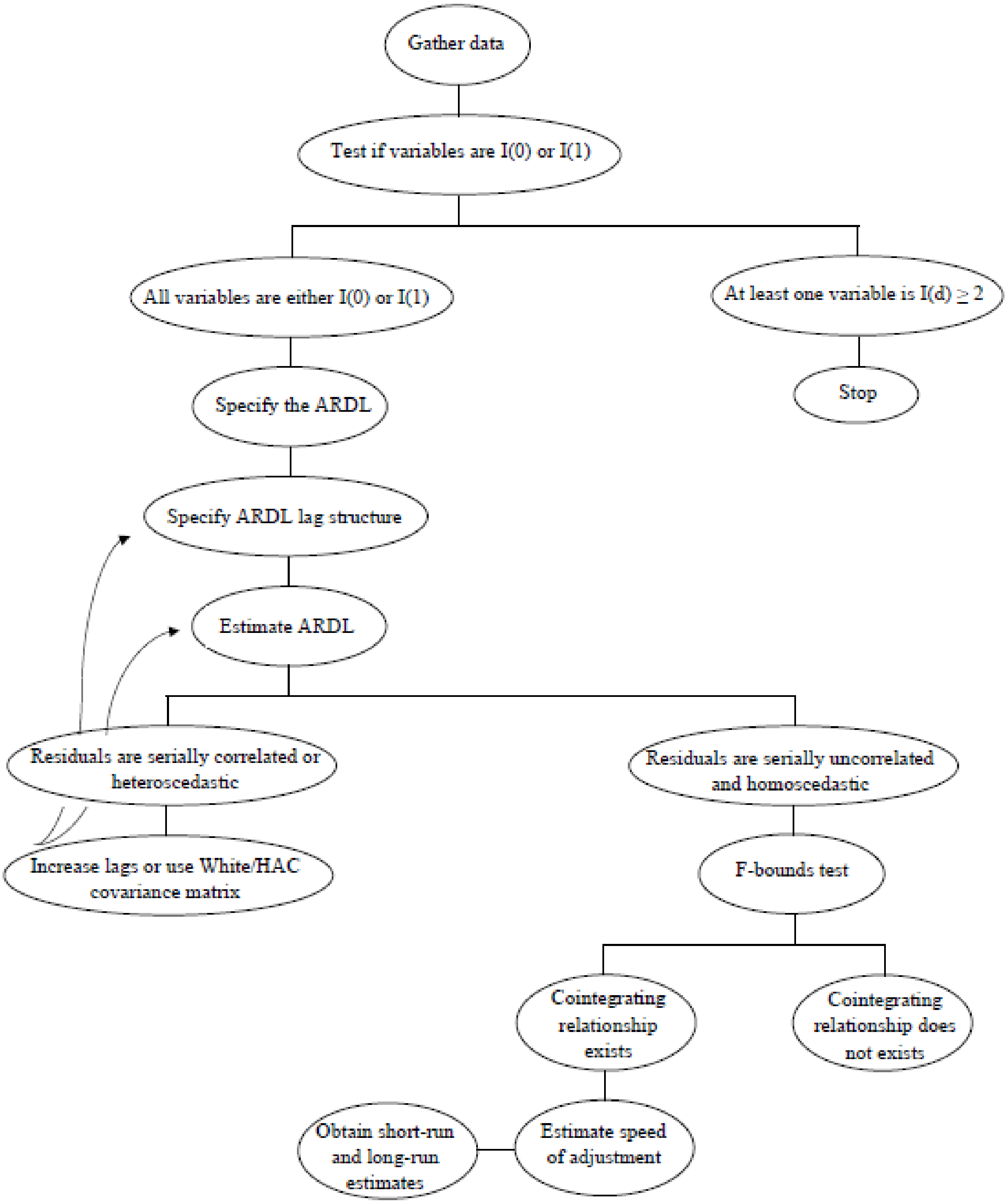

Figure A.1 ARDL Method Overview