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Greenhouse gas emissions, energy consumption and economic growth: A panel cointegration analysis from Canadian industrial sector perspective

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ABSTRACT

This paper investigates the long-run and the causal relationship between greenhouse gas emissions, energy consumption and economic growth for Canadian industrial sectors over the period 1990–2007. The empirical findings suggest that in the long-run equilibrium, energy consumption has a positive and statistically significant impact on greenhouse gas emissions whereas a non-linear relationship is found between greenhouse gas emissions and economic growth, consistent with the environmental Kuznets curve. The short-run dynamics conveys that there is a unidirectional Granger causality running from energy consumption to greenhouse gas emissions; from economic growth to greenhouse gas emissions and a weak unidirectional causality running from greenhouse gas emissions to energy consumption; from economic growth to energy consumption. In the long-run however, there seems to be a weak one way causality flowing from energy consumption and economic growth to greenhouse gas emissions.

1. Introduction

There is widespread agreement among energy economists and policy analysts in Canada and elsewhere that the ever-increasing energy demand is the major contributing factor to anthropogenic greenhouse gas emissions. Energy is essential to all economic activities, however, the increasing attention given to global warming and climate change has renewed spur to research interest in the relationship between environmental pollutants, energy consumption, and economic growth. Nowadays, mitigation assessment of greenhouse gas emissions has become an integral part of the national and international climate policy agenda.

Since the mid-1990s, the Canadian industrial sector has experienced spectacular economic growth. Between 1990 and 2007, industrial energy consumption increased by 28.10%, from 2709.96 petajoules (PJ) to 3471.59 PJ. Accordingly, industrial energy-related greenhouse gas emissions rose by 24.13%, from 135.76 megatonnes of carbon dioxide equivalent (Mt CO_2e) to 168.52 Mt CO_2e. Over the same period, output grew by an average annual rate of 2.32%. In 2007, the industrial sector accounted for about 32% of Canada's total greenhouse gas emissions.

In the Regulatory Framework for Air Emissions (2007), the Canadian government has designed a concrete and ambitious plan to reduce emissions of greenhouse gases in a number of heavy polluting industries. Under this legislation, the targeted sectors are requested to improve their emission-intensity by 6% each year from 2007 to 2010. This yields a reduction of greenhouse gas emissions per unit of production by 18% from 2006 levels in 2010. And then every year thereafter, a 2% annual reduction in emission-intensity is required. This mechanism contributes substantially to the government's commitment to reduce national absolute greenhouse gas emissions by 20% from 2006 levels by 2020.

However, to curb the greenhouse gas emissions and to ensure the sustainability of the economic development, it is important to better understand the link between greenhouse gas emissions, energy consumption, and economic growth. In the literature, there have been three streams of research to explore the relationship between these variables. The first stream of research focuses on the relationship between economic growth and environmental pollutants and suggests an inverted U-shaped relationship between environmental degradation and per capita income/output. This relation is known as the Environmental Kuznets Curve[1] (EKC). Several studies examined the linkage between economic growth and environmental pollutants. Recent studies include Coondoo and Dinda (2002), Dinda

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[1] The Environmental Kuznets Curve introduced in the energy–growth literature refers to the similarity with the relationship between the level of inequality and per capita income considered by Kuznets (1955).

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(2004), Dinda and Coondoo (2006), Akbostanci et al. (2009), Lee and Lee (2009) among others. These empirical studies have been subject to specification bias due to omission of relevant variables. The second stream of research investigates the relationship between energy consumption and economic growth. As emphasized by Apergis and Payne (2009b), an investigation of the energy consumption–growth nexus not only provides insights with respect to the role of energy consumption in economic development, but also provides a basis for discussion of energy and environmental policies. Over the past few decades, the relationship between energy consumption and economic growth has been extensively investigated. Representative studies in this regards are Ghali and El-Sakka (2004), Lee (2005), Lee and Chang (2008), Lee et al. (2008), Payne (2009), Soytas and Sari (2009), Apergis and Payne (2009b, 2010b), Chandran et al. (2010), to mention only a few. The last stream of research combines the two previous by examining dynamically the relationship between emissions, energy consumption, and economic growth, see for instance Soytas et al. (2007), Ang (2007), Halicioglu (2009), Apergis and Payne (2009a, 2010a) and Ozturk and Acaravci (2010) for comprehensive reviews.

Most of these empirical studies focus on using aggregate level data to investigate the relationship between emissions, energy consumption and economic growth. Furthermore, some of these studies make use of time series data which is known to yield unreliable and inconsistent results due to the low power of the unit root and cointegration tests. The use of panel data may increase the sample size allowing for more accurate and reliable statistical tests. Therefore, there are very few empirical work on the topics that have made an attempt to gain statistical power through the pooling of information across units, alas, they have neglected to account for the presence of cross-section dependencies[2] of the data. As has been documented in the literature, failure to adequately account for the presence of cross-section dependence in panel data study could lead to serious bias problem, see for instance O'Connell (1998), Andrews (2005), Pesaran (2006) and Bai and Ng (2010).

This paper contributes to the literature by extending the long-run and the causal relationship between greenhouse gas emissions, energy consumption and economic growth to a panel of Canadian industries over the period 1990–2007. Our analysis covers the industries targeted by the proposed industrial regulations. These industries are responsible for about 56% of the total industrial greenhouse gas emitted in 2007. The aim of the paper is more specifically to determine the nature of the long-run equilibrium and the causal relationship between greenhouse gas emissions, energy consumption and economic growth by taking into consideration the hypothesis of cross-section dependence. To the best of our knowledge, there has never been an attempt to investigate the relationship between these variables within a trivariate framework by employing disaggregate level panel data and considering the presence of cross-section dependence. This study try to fulfil this gap. In this respect, we argue that the examination of the relationship between emissions, energy consumption and economic growth carried out in this paper may be of uttermost importance for policy-makers and decision-makers to better understand the energy–environment–growth dynamics in order to develop effective energy policies that will palliate the impacts of human activities, and thereby contribute to reduce emissions of greenhouse gases while preserving economic growth.

The remainder of the paper is organized as follows. The next section gives a brief review of the existing literature. Section 3 describes the data used in the empirical study. The econometrical methodology and results are provided in Section 4. Section 5 concludes the paper.

[2] Cross-section dependence in panel data may stems, e.g., from oil price shocks and/or international crises which drive the co-movement among the economic variables.

2. A brief literature review

Although there are numerous empirical studies that have contributed to the discussion and understanding on energy–growth nexus.[3] Yet, there appears to be no consensus concerning the direction of causality between energy consumption and economic growth. In the literature, four views pertain. The first view argues that energy consumption stimulates economic growth. However, the second view defend that causality runs from economic growth to energy consumption. The third view asserts that causality runs in both directions between economic growth and energy consumption which suggests economic growth and energy consumption are complementing each other. Lastly, the fourth view maintains that there is no causality between energy consumption and economic growth. The majority of the previous studies address the causal relationship between energy consumption and economic growth within a bivariate framework. Many researchers have pointed out that the use of a bivariate framework may alter the direction of causality between the two variables. By now, there is a broad based econometric studies that have been used to test the validity of energy–environment–growth dynamics within a trivariate framework in both developing and developed countries.

For instance, Zhang and Cheng (2009) use time series to verify the existence of causality between economic growth, energy consumption, and carbon emissions in China over the period 1960–2007. The authors conclude that GDP/energy consumption unidirectionally Granger-causes energy consumption/carbon emissions but neither carbon emissions nor energy consumption causes economic growth. In a study for South Africa for the period 1965–2006, Menyah and Wolde-Rufael (2010) found unidirectional causality running from pollutant emissions to economic growth; from energy consumption to economic growth and from energy consumption to CO_2 emissions all without a feedback. Soytas et al. (2007) undertake a similar study for the United States for the period 1960–2004. Their results indicate that income does not Granger cause carbon emissions but energy consumption does in the long-run. Using autoregressive distributed lag (ARDL) bounds testing approach of cointegration and Engle and Granger procedures, Acaravci and Ozturk (2010) examine the causal relationship for nineteen European countries over the period 1960–2005. Their study establishes short-run unidirectional causality for some countries while for others they found bi-directional causality and for few neutrality.

The general observation that emerges from the existing literature is that most studies on the energy–environment–growth dynamics have employed aggregated level data that led to conflicting results. As has been pointed out by Soytas et al. (2007), disaggregate level data may provide further insight regarding the link between output growth, energy consumption and environmental degradation. Thus, we feel the usage of disaggregated data may elicit the correct diagnosis of energy–environment–growth nexus.

3. Data descriptions

We assemble data on 21 Canadian industrial sectors for the period 1990–2007. The temporal dimension was restricted due to data availability. The data are annual and the industries are under the NAICS (North American Industrial Classification System) classification. The data series were obtained from Canadian Industrial Energy End-Use Data and Analysis Centre (CIEEDAC) and Natural Resources Canada (NRCan). We utilized Industrial energy[4] use in gigajoules

[3] Ozturk (2010) provides a good survey of the recent progress on energy–growth nexus. See also Payne (2010).

[4] Energy is derived from 15 energy sources, namely, Electricity, Natural Gas, Diesel Fuel Oil, Light Fuel Oil, Heavy Fuel Oil, Kerosene, Still Gas, Petroleum Coke, Liquefied Petroleum Gas (LPG), Plant Natural Gas Liquids (NGL), Coal, Coke and Coke Oven Gas, Wood Waste, Pulping Liquor and Other.