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CO_2 emissions, output, energy consumption, and trade in Tunisia

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ABSTRACT

This article contributes to the literature by investigating the dynamic relationship between carbon dioxide (CO_2) emissions, output (GDP), energy consumption, and trade using the bounds testing approach to cointegration and the ARDL methodology for Tunisia over the period 1971–2008. The empirical results reveal the existence of two causal long-run relationships between the variables. In the short-run, there are three unidirectional Granger causality relationships, which run from GDP, squared GDP and energy consumption to CO_2 emissions. To check the stability in the parameter of the selected model, CUSUM and CUSUMSQ were used. The results also provide important policy implications.

1. Introduction

In the last few decades, pollutant emissions can be considered under the heading of the major worldwide on-going concerns. Worldwide organizations, such as the United Nations (UN) or the World Economic Forum (WEF), have been attempting to reduce the adverse impacts of global warming and climate change on the economy. The Kyoto protocol to the United Nations Framework Convention on Climate Change (UFCCC) is one of the important solutions to reduce greenhouse gases (GHG).

Tunisia, as a developing country, has ratified this protocol in 2003 in order to reduce the continuous increase in GHG emissions over time. Returning to the history, the inventory of GHG for 1994 shows a relatively limited contribution to the greenhouse effect. In fact, the net anthropogenic GHG emissions of Tunisia are 23.4 million tons CO_2 equivalent, which represent 2.66 million tons CO_2 equivalent per capita or 1.8 million tons CO_2 equivalent per thousand US$ of GDP. In gross terms, Tunisian emissions presented 28.9 million tons CO_2 equivalent, meaning 3.3 million tons CO_2 equivalent per capita. The GHG absorption totaled 5.5 million tons of CO_2, meaning 0.6 tons of CO_2 per capita. The analysis of the gross Tunisian emissions by source shows a preponderance of energy in the emission balance. In fact, with 15.3 million tons CO_2 equivalent, energy uses represent more than half of the gross national emissions (52.8%), followed by agriculture, which represents with 6 million tons CO_2 equivalent, meaning 20.8% of gross emissions. Next come forests and industrial processes with respectively 3.7 million tons of CO_2 (12.9%) and 2.8 million tons of CO_2 (9.8%) of gross national emissions. Wastes remain a relatively weak source of emissions with only 1 million tons of CO_2, meaning 3.6% of gross Tunisian emissions (Ministry of Environment Land Planning, 2001).

Between 1994 and 2002, both the energy generation and the transport sector have been considered as major contributors to air pollution with 31% and 30%, respectively. With more details, CO_2 emissions account for 92% of the total GHG emissions, while methane (CH_4) emissions account for 7%, and nitrous oxide (N_2O) emissions account for 1%. The transport sector is the top contributor of CO_2 emissions, while GHG emissions of CO_2 from this sector rose from 3.4 million tons to 5.8 million tons, with an annual increase rate of 9%. In the second order, GHG emissions of CO_2 from the energy sector also accounted for 29% in 2002, rising from 23% in 1994 (United Nations Environment Programme, UNEP, 2002, chapter 2). For that, an important program is proposed by the Environment and Management body of the Territory Ministry in collaboration with the National Environment Protection Agency and Tunis International Centre for Environmental Technologies (Centre International des Technologies de l'Environnement de Tunis, CITET). The objective of this program consists to preserve the air quality by identification, characterization and reduction of fixed (industrial sector) or mobile (transport sector) pollutions (Chaaban, 2008).

Between 2005 and 2008, the government has been already allowed by clean energy plans to save $1.1 billion in energy bills, relative to initial investments of $200 million in clean energy infrastructure. In December 2009, the government presented the first national Solar Energy Plan and other complementary plans with the objective of

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increasing the share of energy sources using renewable energy from just under 1% to 4.3% in 2014. To implement this plan, total financial resources have been estimated at $2.5 billion, including $175 million from the National Fund, $530 million from the public sector, $1660 million from private sector funds, and $24 million from international cooperation, all to be spent by 2016 on 40 renewable energy projects. Approximately 40% of the resources are devoted to the development of energy export infrastructure. Expected to result from the Solar Energy Plan, the energy savings could reach 22% for 2016, with a reduction of 1.3 million tons per year of CO_2 emissions.

Indeed, the Tunisian Solar Programme (PROSOL) is a joint initiative between the Tunisian National Agency for Energy Conservation (Agence National de Maitrise de l'Energie, ANME), the Tunisian Company of Electricity and Gas (Société Tunisienne de l'Electricité et de Gaz, STEG), the UNEP and the Italian Ministry for the Environment, Land and Sea (IMELS), provides an example of solar thermal market development. This program has helped more than 105,000 Tunisian families get their hot water from the sun, based on loans of over $60 million, a substantial leverage on PROSOL's initial $2.5 million cost. Financial and fiscal support combines a capital grant qualifying for a value added tax exemption, customs duty reduction and a bank loan with a reduced interest rate. Repayment of the loan is organized through the regular utility bill of the state electric utility STEG, with local banks receiving support that allows them to finance Solar Water Heating (SWH) projects with reduced interest rates. This arrangement has generated direct financial benefits for the end users, when comparing the size of the monthly installments for a SWH system to the earlier electricity bills. A complementary interest rate subsidy was available during the first two years (2005–2006) of the program, reducing the interest rate of the loan to 0% to the final end user.

This support was removed in 2007 and annual interest rates for loan repayment have been 6.5%. The government provides a subsidy of 20% of the system cost or $75 per m^2, while customers are expected to finance a minimum of 10% of the purchase and installation costs. Over 50,000 Tunisian families now get their hot water from the sun based on loans amounting to more than $5 million in 2005 and $7.8 million in 2006. With installed surface of the program reaching 400,000 m^2, the government has set a more ambitious target of 750,000 m^2 for the period 2010–2014, a level comparable to much larger countries such as Spain or Italy. As of 2008, PROSOL helped avoid 214,000 tons of cumulative CO_2 emissions. Many jobs have been created, as 42 technology suppliers and more than 1000 installation companies have sprung up to service the solar market. The tourism and industry sectors are also now involved, with 47 hotels engaged by late 2009, and there are plans to encourage industry to make greater use of the sun's energy (UNEP, 2010).

Recently, some centers and organizations such as the International Centre for Trade and Sustainable Development (ICTSD), the International Trade Centre (ITC), and the World Trade Organization (WTO) conclude that environment and trade are strongly related, and can be mutually supportive. Their essential goal is to propose program on trade, environment and natural resources. This program consists to engage stakeholders and to provide new and innovative thinking on how to make trade policy effectively contribute to sustaining and improving livelihoods in developing countries that depend on natural resources.

Tunisia has been a member of the WTO since 29 March 1995. In collaboration with this organization, Tunisian economists have developed a conceptual framework for examining how trade opening can affect environment and pollution. This framework, first applied to study the environmental impact of the North American Free Trade Agreement (NAFTA), separates the impact of trade liberalization into three independent effects: scale, composition and technique. Firstly, the scale's effect indicates the impact on GHG emissions from the increased economic activity resulting from trade. The fundamental conclusion is that trade opening will increase economic activity and hence energy use. Everything else being equal, this increase in the economic activity scale and energy use will lead to higher levels of GHG emissions. Secondly, the composition's effect refers to the way that trade liberalization changes the mix of a country's production towards those products where it has a comparative advantage. The effect on greenhouse gas emissions will depend on the sectors in which a country has comparative advantage. The principal conclusion of this effect will result in less GHG emissions if the expanding sectors are less energy intensive than the contracting sectors. Whether the composition effect results in higher or lower greenhouse gas emissions is therefore difficult to predict in advance. Finally, the technique's effect proves that trade opening can lead to improvements in energy efficiency. This means that the production of goods and services can generate less GHG emissions, the increase in the availability of goods, services and technologies improves energy efficiency, and the trade can help to meet the challenge of global warming (WTO, 2013).

Empirically, as the linkage between trade openness and environmental performance is not sufficiently studied at the empirical level, this paper proposes to make a contribution to the existing literature by examining the causal relationship between CO_2 emissions, real GDP, energy consumption, and trade openness in Tunisia for the 1971–2008 period using recent robust econometric techniques. Specifically, we contribute to the literature in three ways. First, until now, no study has emphasized the importance of this subject for a developing country such as Tunisia. Second, the analysis will be undertaken within an environmental model framework by including at the same time measures of energy consumption and trade openness using the bounds testing approach to cointegration and the ARDL methodology. Third, the sign and magnitude of the respective coefficients will be discussed in relation to the various hypotheses on the relationship between variables.

The remainder of this paper is organized as follows. Section 2 investigates the literature review. Section 3 introduces the data and our methodology. Section 4 discusses our empirical results. Section 5 states the conclusion and policy implications.

2. Literature review

The impact of economic growth, energy consumption and trade openness on the environment has become a dominant question in the recent economic literature. This subject has been mostly examined within the framework of Environmental Kuznets Curve (EKC) in order to suggest the existence of an inverted U-shaped relationship between environmental pollution and per capita income.

Many studies within the context of the EKC are completely devoted to test the validity of the EKC hypothesis for a single country and/or a balanced panel. But in general, these studies can be classified on three categories of empirical researches. The first category consists to study the dynamic relationship between economic growth and environmental pollutants, or between economic growth, energy consumption and environmental pollutants (Ang, 2007; Apergis and Payne, 2009; Chebbi, 2010; Ekins, 1997; Fodha and Zaghdoud, 2010; Gale and Mendez, 1998; Grossman and Krueger, 1995; Selden and Song, 1994; Stern and Common, 2001; Stern et al., 1996; Vincent, 1997), whereas the second category was focused to examine the dynamic relationship between economic growth, energy consumption, environmental pollutants and trade (Halicioglu, 2009; Jalil and Mahmud, 2009; Jayanthakumaran et al., 2012; Suri and Chapman, 1998). The last category presents the inclusion of other variables depending on the country or the panel of countries studied (Farhani, 2012a; Farhani et al., 2014).

For the first category which does not include trade, Grossman and Krueger (1995), Selden and Song (1994), Vincent (1997), and Gale and Mendez (1998) investigated the impact of economic growth on environmental degradation. But these studies have been criticized by Stern et al. (1996), Ekins, (1997), and Stern and Common, (2001) because the methodological choices of pollutants can significantly influence to change the results. Recently, the literature of the dynamic relationship between pollutant emissions, energy consumption and