Renewable and Sustainable Energy Reviews 25 (2013) 34–43

Contents lists available at SciVerse ScienceDirect

Renewable and Sustainable Energy Reviews

journal homepage: www.elsevier.com/locate/rser

Indicators for sustainable energy development: A multivariate cointegration and causality analysis from Tunisian road transport sector

Khaled Ben Abdallah [a], Mounir Belloumi [b,*], Daniel De Wolf [c]

[a] Higher Institute of Transport and Logistics of Sousse, University of Sousse, Tunisia
[b] Faculty of Administrative Sciences, Najran University, Saudi Arabia and LAMIDED, University of Sousse, Tunisia
[c] Faculty of Economics and Management and TVES, University of Littoral, France

ARTICLE INFO

Article history:
Received 8 December 2012
Received in revised form
14 March 2013
Accepted 18 March 2013

Keywords:
Sustainable energy development
Johansen's cointegration approach
Environmental Kuznets curve
Transport sector
Tunisia

ABSTRACT

This paper studies causal mechanism between indicators for sustainable energy development related to energy consumption from Tunisian road transport sector. The investigation is made using the Johansen cointegration technique and the environmental Kuznets curve (EKC) approach. It examines the nexus between transport value added, road transport-related energy consumption, road infrastructure, fuel price and CO_2 emissions from Tunisian transport sector during the period of 1980–2010.

Empirical results show that road transport-related energy consumption, transport value added, transport CO_2 emissions and road infrastructure are mutually causal in the long-run. These results do not support the hypothesis of neutrality between energy and income for the Tunisian road transport sector. Also, there is a unidirectional causality running from fuel price to road transport-related energy consumption with no feedback in both the short and long runs. The fuel price and the road infrastructure are significant in the causal chain. Though the estimated long-run cointegrated equation, we conclude that there is an inverse *N*-shaped relation between transport value added and transport CO_2 emissions, with income turning point respectively equal to 75 and 579 (constant 2000 TND prices). Therefore, our empirical findings refute the hypothesis of an inverted *U*-shaped EKC for transport CO_2 emissions in Tunisia.

The findings of this study have a number of policy implications. Economic growth, environmental degradation, energy and transportation policies should be recognized in order to improve the energy efficiency in transport sector. All measures that should reduce petroleum consumption and greenhouse gas emissions without affecting economic growth may be undertaken. The policymakers in Tunisia should plan urban transport, relocate production units, improve fuel-efficient vehicles and reinforce legislation on controlling emissions in order to copying with policies based on low-carbon development and climate-resilient strategies.

Contents

1. Introduction

The energy sustainability requires development modes which provide reliable energy services at a less cost, demand few of

* Corresponding author. Tel.: +966530948710; fax: +96675428887.
E-mail addresses: mounir.balloumi@gmail.com, mounir.belloumi@fdseps.rnu.tn (M. Belloumi).

1364-0321/$ - see front matter © 2013 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.rser.2013.03.066

energy and produce few of polluting gas. Energy consumption is a serious problem for developing countries and it is strongly linked to gas emissions. Consequently, economic growth, which uses more energy and produces more pollutant gas, is considered unsustainable and it affects negatively public health [1–7]. Since 1999, IAEA [8–10] has been working on the construction of socio-economic and environmental indicators for sustainable energy development. Economic, demographic, urban, and technological factors can influence energy consumption and so as gas emissions [11–15].

To evaluate the energy sustainability degree of transport sector, it is necessary to determine the driving factors influencing transport-related energy consumption such as economic growth, energy price, urban population, transport activity, motorization rate, traveling distance, park structure, vehicle types, vehicle age, urbanization, national road network and transport intensity. The main objective was to define cause and effect relationships between these indicators in order to formulate appropriate policies increasing the energy sustainability in the transport sector.

Recently, interest in the causality question has gained more attention to the concerns about climate change with following proposals to limit CO_2 emissions by restricting fossil fuel consumption. Literature on this topic has been interested in an aggregate and disaggregates contexts. More existing methods have presented to examine the causal mechanisms between energy consumption, economic growth, environmental degradation and social development.

Although transport sector is considered an important consumer of energy, this problematic is empirically less studied in the sustainable transport literature. In this sense, three principal approaches are adopted: the cointegration and causality analysis, environmental Kuznets curve model and the decomposing analysis method.

In Tunisia, energy consumption related to the transport activity is still continuous to increase with a share more than 34% of total energy consumption in 2010 [16]. Road transport is considered the important source responsible for combustible fossils consumption with a share of more than 70% of total transport related energy consumption in 2010. Consequently, its contribution in total CO_2 emissions is important comparatively to other activities. The CO_2 emissions from road transport have increased from 1.75 million metric tons in 1980 to 4.94 million metric tons in 2010, representing more than 27% of total CO_2 emissions [16]. Road transportation affects environment by emitting greenhouse gases, and environment also affects road transportation through climate change.

Transport sector has to meet many challenges. It has to fulfill the challenge of economy, society and environment. This suggests that government in Tunisia should elaborate some strategies in order to reduce its energy consumption and to make it more sustainable. Action is needed to restrict the use of fossil fuels: Tunisian Government should elaborate a sustainable transport strategy that takes into account the rising of fossil fuels consumption and the negative effects of CO_2 emissions at the same time.

Different measures have been proposed for sustainable transport to copy with climate policy. They are classified into two policy measures—renewable energy development (such as bio-fuels) versus reduction of energy consumption. The restriction of transport-related energy consumption can be achieved by using economic instruments such as fuel or carbon taxes. However, the strategy of reducing transport energy consumption can have negative effects on economic growth. Policy makers should be aware of the nexus between transport energy and economic growth for both energy and environmental policies.

This paper studies causal mechanism between per capita transport value added (PCTVA), per capita road transport-related energy consumption (PCRTEC), per capita road infrastructure (PCRI), per capita CO_2 emissions from Tunisian transport sector ($PCTCO_2$) and fuel price (FPrice) during the period 1980–2010 using the cointegration technique and Environmental Kuznets Curve model. We consider a multivariate model rather than the usual bivariate approach in order to investigate other channels in the causal links between indicators for sustainable energy development from the Tunisian road transport sector. Our study is one of the few studies which focus on the relationship between energy consumption, GDP and CO_2 emissions on disaggregated level. The choice of transport sector is guided by the strong connection between road transportation and sustainable development. Its purpose is to provide an insight for policy-makers in the choice and the implementation of adequate strategy reducing road energy consumption. For example, if causality runs from road transport energy consumption to transport value added, then restricting its use may impede transport GDP. However, if such causality direction runs only from transport GDP to road transport energy, then a conservation policy may be desirable.

The remainder of the paper is organized as follows: Section 2 presents a review of literature on relationships between various indicators for sustainable energy development. It also outlines some methods used in order to analyze the interaction between transport, energy, economic and environment areas. Section 3 describes Tunisia's transport activity in order to show the evolution of the indicators for sustainable energy development during the period 1980–2010. Section 4 presents policies adopted in Tunisia to reduce the use of energy in the transport sector. In Section 5, we present the data, the methodology and analyze the empirical results.

2. Empirical literature review

In literature, a large majority of studies [17–19] have discussed the question for relationship between transport activity, economic growth and environmental effects in order to elaborate an efficient transport policy [20–22]. Literature review shows several approaches such as causality test, environmental Kuznets curve model and decomposing analysis.

Concerning causality tests, studies show many controversies in terms of causality sense. The causal relationships can be unidirectional or bidirectional or absent. The divergence of results is mainly attributed to the difference of empirical methods used and the choice of period of study. Since the original paper of Kraft and Kraft [23], many empirical works have analyzed the cointegration relationship between economic growth and energy consumption [24–30].

For the case of Iran, Lotfalipour et al. [31] have studied the causal relationships between economic growth, carbon mission and fossil fuels consumption during the period 1967–2007. The energy consumption has been decomposed into three components: total consumption of fossil fuels, petroleum products and natural gas. The authors have found a unidirectional causality from economic growth, petroleum products and natural gas consumption to carbon emissions. Also, they have found that carbon emissions, petroleum products and total fossil fuels consumption are not cointegrated to economic growth. The most important implication is the independence between energy and economic growth. In Tunisia, Belloumi [32] has examined the same problematic along the period 1971–2004 by using the Johansen cointegration technique. He has shown a unidirectional causality from economic growth to GDP in the short-run and bidirectional causality in the long-run.

Gas emissions are strongly linked to energy consumption especially fossils combustibles [33]. Environmental impacts caused by gas emissions due to energy consumption depend on quantities of energy required by economic growth. Consequently, economic growth, that use more energy and produce more pollutant gas, is