Energy Policy 62 (2013) 247–253

Contents lists available at ScienceDirect

Energy Policy

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

Road transport-related energy consumption: Analysis of driving factors in Tunisia

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HIGHLIGHTS

- We are interested in determining driving factors of transport energy consumption growth in Tunisia.
- We use decomposition analysis approach.
- Vehicle fuel and road vehicle intensities are found to be principal factors.
- Motorization and urbanization are also found to be responsible.

ARTICLE INFO

Article history:
Received 24 June 2012
Accepted 2 July 2013
Available online 8 August 2013

Keywords:
Energy intensity
Transport sector
Decomposition analysis

ABSTRACT

The rapid growth of urban population and the development of road infrastructures in Tunisian cities have brought about many environmental and economic problems, including the rise scored in energy consumption and the increase in the quantity of gas emissions arising from road transport. Despite the critical nature of such problems, no policies have yet been adopted to improve energy efficiency in the transport sector. This paper aims to determine driving factors of energy consumption change for the road mode. It uses decomposition analysis to discuss the effects of economic, demographic and urban factors on the evolution of transport energy consumption. The main result highlighted in the present work is that vehicle fuel intensity, vehicle intensity, GDP per capita, urbanized kilometers and national road network are found to be the main drivers of energy consumption change in the road transport sector during 1990–2006 period. Consequently, several strategies can be elaborated to reduce road transport energy. Economic, fiscal and regulatory instruments can be applied in order to make road transport more sustainable.

1. Introduction

Several factors contribute remarkably not only to the increase but also to the decrease in the consumption of transport combustible fossils as well as in the quantity of gas emissions. In Tunisia, energy consumption in the transport sector continues to rise. It represents 34% of total energy consumption in 2010. Particularly, the road mode has the highest rate of passenger vehicle gasoline and diesel consumption, with 70% of total transport energy consumption in 2010. Determining a set of driving factors is one of the chief procedures to be adopted so as to identify the causes ushering in the changes in the road transport energy consumption. Basically, it leads us to opt for specific solutions, the purpose of which is to improve energy efficiency and render the transport sector more sustainable. Several factors can be presented in this context, such as types of fuels used by vehicles, traveled distances, vehicle weight, vehicle age, vehicle speed, driving conditions and modal mix. We consider in this paper an array of economic, demographic, urban and technological factors. Our objective is to discuss their effects on road transport energy consumption in Tunisia over the 1990–2006 period. Particularly, this paper examines the effects produced by vehicle fuel intensity, vehicle intensity, income, urbanized kilometers and road network. In other terms, the present work identifies measures and analyzes the effects of vehicle fuel use, vehicle's demand, and buying power in addition to the effects of urbanization. The evolution of motorization, the growth of urban population and urban density, and the rise in the number of private vehicles are used to understand the effects mentioned above and equally the road network length. Determining the effects of driving factors during the specified period could contribute to the elaboration of transport energy conservation strategies through the use of some political and technical measures.

This paper is structured as follows: Section 2 provides a brief overview of the literature on energy efficiency and the main

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http://dx.doi.org/10.1016/j.enpol.2013.07.007

factors affecting it in the transport sector. Transport intensity and energy intensity are some main key concepts required in the analysis of the relationship between road transport and energy consumption. Section 3 goes into detail about road transport and energy consumption in this sector in Tunisia. Section 4, firstly, presents the main factors which influence road-related energy consumption and the methodology of decomposition technique and secondly, discusses results and proposes some policy options to conserve road transport energy consumption.

2. Transport energy saving: literature review

Transport energy consumption has been recurrently discussed in the literature. The link between economic activity, transport activity and transport energy use is one of the main relations that should be treated to examine adequately the use of transport energy. The close relationship between transport and economic activity implies that economic growth improves the transport intensity and, so, leads to the deterioration of transport energy efficiency. The decoupling between growth in the transport activity and economic growth is often taken as a solution to reduce transport energy use.

Transport intensity and energy intensity indicators are used as important tools in the analysis of the relationship between economic growth, energy consumption and changes in the quantity of gas emissions from the transport sector. Kiang and Schipper (1996) have decomposed transport energy efficiency into three factors: transport activity (transport volume), modal structure (share of every modal) and energy average use. They have shown that technical progress is insufficient not only to achieve the decoupling between economic growth and the growth of transport demand but also to restrain the increase of transport demand and to stop the evolution of road transport share. It can be used to accomplish solely a partial decoupling. Ang and Zhang (1999) have used energy efficiency and GDP as explicative factors of gas emissions produced by combustible fossils in three countries groups in OECD. Vanek and Morlok (2000) have shown that the reduction of energy consumption in the road freight transport sector requires for its success a synchronization of technological, operational and modal policies. Stead (2001) proposed several indicators of transport intensity and investigated the energy efficiency and economic performance of the transportation system from 1970 to 1995 in European Union members. The principal result of these studies is that aggregated indicators of transport demand make a problem for estimation of transport intensity. Herzog et al. (2006) have considered the composition of energy as a factor of decomposition and they have found that emissions have been reduced with a high quality of energy but increased with economic growth.

In order to study transport-related energy consumption, the majority of works have used the decomposition method. It is one of the most effective applied tools used to investigate the factors influencing energy consumption and its environmental impacts. The decomposition method dates back to studies undertaken in the 1980s. The decade has known an expansion with works drawing upon the evaluation of aggregate energy consumption caused especially by the preceding energy crisis. This had been evoked especially in the industrial context (Howarth et al., 1991; Park, 1992). However, in the 1990s and the 2000s this technique has been generalized to be used and applied to other sectors such as transport sector. The main objective of this method is to identify factors that influence directly or indirectly energy consumption. One of the important decomposition of energy efficiency is proposed by Kaya (1989). Kolb and Wacker (1995) have used decomposition method to find determinants of energy consumption and greenhouse gas emissions.

Several studies have been interested in decomposing energy consumption in the transport sector in order to show the contribution of traffic in pollution. Schipper et al. (1997) have decomposed energy intensity into three factors: transport activity (tonne kilometer), structure of transport (types of modals) and intensity (energy used per unit of transport). They have concluded that best energy efficiency cannot compensate increasing of transport and modal share of road transport. Fosgerau and Kveiborg (2004) have decomposed the energy intensity of road transport for Denmark along the period 1981–1997. They have found that energy efficiency has been ameliorated through reduction of industrial production share and distance traveled through implantation of logistic platforms. Steer Davies Gleave (2003) have concluded, for the case of Germany, France, Spain, Italy and England during the period 1970–2000, that reduction of the road transport share has ameliorated the energy efficiency for the countries group. Steenhof et al. (2006) have used decomposition of energy intensity in order to examine the determinants of GES caused by freight transport in Canada. They have concluded that technical progress is an inadequate solution if the share of freight road transport increases for USA. However with these studies more other factors can be missed or less analyzed despite the nature of their main effects. Transport intensity or energy intensity is often aggregate indicators which can neglect some main information concerning efficiency use of vehicles, public transport and road network. Buying power, motorization, urbanization, and investments on road infrastructures are some examples of these main driving factors. Few studies have taken them into account. The objective of such studies is limited to the examination of their correlation with energy consumption through econometric models or causality relationship tests. Rudra (2010) explores the causality relationship between transport infrastructure, energy consumption and economic growth in India over the period 1970–2007. Marshall et al. (2011) explores the causal relationship between residential location and vehicle miles of travel, energy consumption and CO_2 emissions in Chicago metropolitan area over the period 2007–2008.

3. Road transport-related energy consumption in Tunisia

Transport activity in Tunisia is closely linked to energy consumption especially combustible fossils. During the period 1990–2006, transport-related petroleum consumption has increased with an average annual growth rate of 2.98%. It took the highest share before all other sectors. Transport energy use increased from 1045.2 Kilos tones oil equivalent (Ktoe) in 1990 to 1724 in 2006 (Table 1).

Table 2 displays the evolution of the modal mix for freight transport energy use in Tunisia from 1990 to 2006. Road mode has the highest energy consumption which has increased from 811 ktoe in 1990 to 1502 ktoe in 2006.

The road transport energy use is linked to many factors such as national road vehicles park, economic activity, population growth, national road network, motorization, urbanization, prices of fuels, public subsidies and organization of road transport market. The growth of road transport energy use can be attributed to the use of road modal. For example, freight is more transported by road mode than other modes. Table 3 displays the disequilibrium use of transport modes with a dominance of road mode share.

The ton-kilometers for road transport have increased from 9450 mtkm in 1990 to 21,290 in 2006. However, for railway transport, it has increased from 1820.33 mtkm in 1990 to 2174 in 2006. Several factors can explain the evolution of road mode use; for example, availability, flexibility, lower costs, rapidity, and institutional organization. Since the 1980s, Tunisia's road freight transport has been liberated and so it has witnessed important