



Decomposing the influencing factors of energy consumption in Tunisian transportation sector using the LMDI method

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ABSTRACT

Due to rapid economic development and accelerated urbanization, Tunisia's transport sector has experienced a dramatic growth that leads to excessive demand for fossil fuel energy. This study identifies the driving factors and measures their corresponding contributions in transportation energy consumption for the case of Tunisia by using the logarithmic-mean Divisia index method (LMDI) over the period 1985–2014. The transport related energy consumption is decomposed into energy intensity, transportation structure effect, transportation intensity effect, economic output, and population scale effects according to the driving mechanism. Results indicate that the overall effect of economic output, transportation intensity, population scale, and transportation structure on energy consumption is positive, whereas the overall effect of energy intensity is negative. It was shown that energy intensity played the dominant role in decreasing energy consumption during the study period. Improving the transport intensity exerts significant effect on saving energy. Our empirical findings provide scientific supports for the policy measures based on low greenhouse gas emissions integrated transport.

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1. Introduction

The transportation sector plays a crucial role in the rise of economic activity of a society and the sustainability of the earth. Indeed, transport volumes and structures change drastically because of economic and social development in the country. Nevertheless, these changes are associated with increasing energy consumption and negative impacts on the environment, e.g. emissions of greenhouse gases and toxic air pollutants affecting not only the micro and macroclimate but also health. In Tunisia, transportation sector accounts for an important share of energy consumption especially the petroleum products. Obviously, it represents more than 47% of total petroleum energy consumption in 2010 (Ben Abdallah et al., 2013). Particularly, highways transportation mode encompasses a plethora of activities relevant to the movement of freight and mobility of passengers and as such it is considered the main contributor responsible to depletion of fossil fuels, with a share of more than 70% of total energy transport energy consumption in 2010 in Tunisia (Mraihi et al., 2013). It is generally regarded in the literature that changes to fuel use in transportation sector are likely to grow up further with economic

activity, population growth, urban sprawl and rapid industrialization, which make Tunisia confront several challenges. Indeed, decreasing of the CO₂ emissions is the main concern in developing sustainable transport worldwide. Sustainable transport refers to a transport system that meets the needs of the present generations without compromising the ability of future generations to meet their transport needs (Richardson, 2005). Therefore, according to Loo (2008), it is not a single challenge but numerous interrelated challenges such as conflicting environmental, economic and social challenges (Loo and Li, 2012). Hence, it is necessary for Tunisia's government to elaborate some strategies in order to improve energy efficiency and investigate the driving factors which influence the changes in the transportation energy consumption in order to render this sector more sustainable.

Nowadays, there are two renowned branches for decomposition approaches, which are used to quantify and identify factors that influence directly or indirectly transport related energy consumption. These methods are index decomposition analysis (IDA) and structural decomposition analysis (SDA) (Ang, 2004). In this study, IDA method was chosen in order to reduce data requirements and because structural share of a sub-sector is not assessed in SDA (Hoekstra and Van den Bergh, 2003). The IDA method has been previously applied to various countries' passenger and freight transport sectors. Furthermore, IDA analysis can be applied for time series (Zhang et al., 2011). Ang and Zhang (2000) identify two main types of IDA method, which are typically based on the Divisia

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Index and on the Laspeyres Index (Ang and Zhang, 2000; Sun, 1998). These decomposition techniques have been obviously employed since their initial adoption in the 1980s and 1990s (Mark et al., 2013). The Divisia Index Decomposition, especially, the Logarithmic Mean Decomposition Index is used in this research due to its adaptability, operability, ease of understanding and result interpretation. In addition, this technique works effectively on a theory basis (Ang, 2004). However, this method suffers on one complication due to its logarithmic terms. This complication arises when the data set contains zero values. In this case, Ang and Choi (1997) proved that a very small number should replace the zero value.

This study is concerned about the question of what factors have the most influence on transportation energy consumption in Tunisia. Knowledge of the nature of driving factors is essential to the decision makers in countermeasure development and strategic planning to realize the goal of transport related energy consumption reduction.

So, we use the LMDI method to analyze the Tunisian transportation sector over the period 1985–2014, identify the driving factors and measure their corresponding contributions in transport related energy consumption.

The remaining part of this paper is organized as follows. In Section 2, we provide an overview of the related literature followed by a brief description of the Tunisian transportation energy consumption in Section 3. The data and methodology are presented in Section 4. Section 5 shows empirical results and their discussion. The final section concludes the paper.

2. Literature review

A large number of decomposition techniques are now available in the energy and environmental literature. Among them, Index Decomposition Analysis is widely used to identify the direct and indirect factors affecting a system's emission changes or energy consumption. In the international literature, there exist numerous studies, which have been devoted to investigate the decomposition analysis in the transportation sector. Based on the index decomposition analysis, Zhang et al. (2011) have used the LMDI method to identify the nature of factors influencing the change in transportation energy consumption. They have concluded that transportation activity effect is the most important contributor to increase of energy consumption. In addition, they found that energy intensity effect plays a dominant role in decreasing energy consumption. For the case of Canada, Steenhof et al. (2006) have used decomposition approach of energy intensity in order to examine the determinants of greenhouses emissions caused by freight transport. Results show that technical progress is not an appropriate solution. Lynn et al. (1996) have used decomposition method to analyze the influences of transport activity, the mix of travel modes, energy intensity, CO₂ intensity and fuel mix on the increase of CO₂ emissions in nine OECD countries. They have discovered that travel-related activity was the major cause of emission increase. For China, Qipeng et al. (2013) have used LMDI decomposition method to identify the driving factors of regional transportation energy consumption. They found that the impacts from scale and technique effects are weakening while that from structure effect is increasing on energy consumption. Shrestha and Timilsina (1996) utilized the Divisia decomposition approach to examine the effects of fuel mix, fuel quality and generation efficiency from thermal power plants on CO₂ intensity in 12 selected Asian countries during the period of 1980–1990. Greening et al. (1999) adopted the adaptive weighted Divisia index to analyze energy consumption and carbon intensity of the freight sector of ten OECD countries. Mazzarino (2000) identified the key factors

affecting the variation of CO₂ emissions from the transport sector in Italy during the period of 1980–1995. He decomposed CO₂ emissions into five components: fuel mix, energy intensity, modal structure, transportation intensity and economic growth. He found that the GDP growth was the main cause of the increase in CO₂ emissions. Lu et al. (2007) have adopted decomposition method to explore the impact of driving factors on total carbon dioxide emission coefficient. They have concluded that rapid growths of economy and vehicle ownership were the most important factors for the increase of emissions. Steckel et al. (2011) have used decomposition analysis of China's CO₂ emissions. Results show that, from 1971 to 2000, the impact of high economic growth on CO₂ emissions was partially compensated by a steady fall in energy intensity. However, the rising carbon intensity of energy from 2000 to 2007 made CO₂ emissions grow rapidly. Zhou et al. (2012) analyzed the coordination relation between energy consumption in the development of comprehensive transportation. For the case of United Kingdom, Sorrell et al. (2010) conducted a formal decomposition analysis of road freight energy consumption. Their results showed that the main factor contributing to energy consumption was the value of manufactured goods relative to GDP. Zhang (2000) analyzed the relationships of fuel mix, energy saving, economic productivity and population expansion to the increase of China's CO₂ emissions over the period 1980–1997. Li et al. (2008) investigated the dynamic relationship between energy efficiency and economic growth in the transportation industry. Zheng and Zhang (2009) evaluated the energy consumption affecting factors of China's regional transportation from four aspects, i.e., natural geographical environment, transportation structure, economic development level and traffic network density. Zhang and Da (2015) combined the decoupling index with the LMDI method to analyze the contribution of the factors that influence energy-related CO₂ emissions in China over the period 1996–2010. Their results indicated that economic growth appeared as the main driver of carbon emissions increase in the past decades, while the decrease of energy intensity and the cleaning of final energy consumption structure played an important role in curbing carbon dioxide emissions.

However, in the national literature, only one study put the accent on the decomposition analysis in the case of Tunisia. In this work, Mraïhi et al. (2013) investigated the LMDI method to identify the driving factors of energy consumption change for the road mode over the period 1990–2006. They concluded that vehicle fuel intensity, vehicle intensity, economic growth, urbanized kilometers and national road network are found to be the major contributors of energy consumption change in the road transport sector.

As mentioned earlier, our work builds on the previous literature and makes an original contribution by extending the conventional decomposition practice to investigate the driving factors of energy consumption change for the demand of mobility of each mode of transportation system. The improvement of existing estimates of passenger and freight-kilometer data is the first thrust of this study. Generally, the small sample sizes do not reflect the actual situation for fossil energy consumption in Tunisia. This study also decomposes the transportation energy consumption over the period 1985–2014. There has only one previous decomposition analysis of the Tunisian transport sector.

3. Overview of transport related energy consumption in Tunisia

During the last decades, the Tunisian transportation sector was the largest energy consumer, especially the petroleum products with average annual growth rate of 2.98% (Mraïhi et al., 2013).

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