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Energy, pollution, and economic development in Tunisia



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ABSTRACT

Since the United Nations Conference on Environment and Development held its Rio meeting in 1992, where participants discussed the necessity of fighting against the hazardous effects of pollution and climate change, these issues have become even more pressing world-wide. The ever-increasing consumption of energy is depleting the planet's natural capital to a degree that could impact our future prosperity. According to the 2008 *Living Planet Report*, if demands for energy were to continue to grow at their current rates, by the mid-2030s we would need the equivalent of two planets to meet our global supply needs.¹

The rising level of energy consumption that is occurring internationally also is being mirrored at regional and national levels. An interesting case study along these lines is Tunisia, which is one of the high-growth economies in the Middle East and North African area yet lacks sufficient energy supply to satisfy its growing demand. Tunisia looks like many nations around the world with a young population, growing economy, increasing domestic energy consumption, and the need to balance economic development with environmental concerns.

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1. Introduction

Climate change has received great attention during the last decade for its impacts on human ecosystem and on the economy. One of the most questions worried out the researchers is: How can we attenuate negatives effects of climate change caused by CO₂ emissions? The world wide has discover the danger of climate change and the necessity to develop meaningful and rigorous policies and procedures whose primary objective is protecting environment and attenuating gas emissions at the atmosphere. The Johannesburg Summit 2002 on sustainable development reaffirmed the central role of energy as an engine of economic development, social equality and poverty alleviation. In this Summit, it was pointed out the disastrous and harmful impact of energy as a cause of pollution and over exploitation of resources on human health and the environment. The action plan of Johannesburg Summit 2002 has reaffirmed after the commission on sustainable development in its ninth session in 2001, the

necessity of developing policies and regulatory frameworks that create economic, social and institutional conditions required for expanded access to reliable energy services and environmental friendly. Research in the link between energy consumption, economic growth and CO₂ emissions has widely analyzed and it was been center of controversial and debate. Energy and climate change are intrinsically linked. The way in which we consume energy largely determines society's environmental impact. For this reason, examining energy use is one of the most fundamental ways that can help in obtaining sustainable development. The awareness on climate change and its repercussions makes it essential that there is some understanding of the causal effects of energy consumption on development. This paper begins with a brief review of the literature on causality link between economic growth, energy consumption and CO₂ emissions. The next section highlights data and methodology and empirical results and the last one concludes and states the policy implications of the results.

2. Literature review

The relationship between energy consumption and economic growth, as well as economic growth and environmental pollution, has been one of the most widely investigated in the economic literature in the three last decades. However, existing outcomes have varied considerably. Whether energy consumption stimulates, retards or is neutral to economic activities has motivated

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¹ World Wildlife Federation (WWF), *Living Planet Report 2008*(Gland, Switzerland: WWF, 2008).

curiosity and interest among economists and policy analysts to investigate the direction of causality between energy consumption and economic variables. The pioneer study by Kraft and Kraft (1978) found a uni-directional Granger causality running from output to energy consumption for the United States using data for the period 1947–1974. The empirical outcomes of the subsequent studies on this subject which differ in terms of the time period covered, country chosen, econometric techniques employed, and the proxy variables used in the estimation, have reported mixed results and supports and is not conclusive to present policy recommendation that can be applied across countries. Depend upon the direction of causality; the policy implications can be considerable from the point of view of energy conservation, emission reduction and economic performance. Most of the analyses on this topic have recently been conducted using Vector Autoregression (VAR) models. Earlier empirical works have used Granger (1969) or Sims (1972) tests to test whether energy use causes economic growth or whether energy use is determined by the level of output (Akarca and Long, 1980a,b; Yu and Hwang, 1984). Their empirical findings are generally inconclusive. Where significant results were obtained they indicate that causality runs from output to energy use. With advances in time series econometric techniques, more recent studies have tended to focus on vector error-correction model (ECM) and the cointegration approach. Masih and Masih (1996) used cointegration analysis to study this relationship in a group of six Asian countries and found cointegration between energy use and GDP in India, Pakistan, and Indonesia. No cointegration is found in the case of Malaysia, Singapore and the Philippines. The flow of causality is found to be running from energy to GDP in India and from GDP to energy in Pakistan and Indonesia. Using trivariate approach based on demand functions, Asafu-Adjaye (2000a,b) tested the causal relationship between energy use and income in four Asian countries using cointegration and error-correction analysis. He found that causality runs from energy to income in India and Indonesia, and a bidirectional causality in Thailand and the Philippines. Stern (2000) undertakes a cointegration analysis to conclude that energy is a limiting factor for growth, as a reduction in energy supply tends to reduce output. Yang (2000a,b) considers the causal relationship between different types of energy consumption and GDP in Taiwan for the period 1954–1997. Using different types of energy consumption he found a bi-directional causality between energy and GDP. This result contradicts with Cheng and Lai (1997a,b) who found that there is a uni-directional causal relationship from GDP to energy use in Taiwan. Soytaş and Sari (2003) discovered bidirectional causality in Argentina, causality running from GDP to energy consumption in Italy and Korea, and from energy consumption to GDP in Turkey, France, Germany and Japan. Paul and Bhattacharya (2004a,b) found bidirectional causality between energy consumption and economic growth in India. Wolde-Rufael (2005) investigates the long-run and causal relationship between real. Using cointegration analysis, Wietze and Van Montfort (2007) show that energy consumption and GDP are co-integrated in Turkey over the period 1970–2003 and found a unidirectional causality running from GDP to energy consumption indicating that energy saving would not harm economic growth in Turkey. The relationship between output and pollution level has also been well discussed in the literature of Environmental Kuznets Curve (EKC) where environmental degradation initially increases with the level of per capita income, reaches a turning point, and then declines with further increases in per capita income (Grossman and Krueger, 1991a,b; Shafik and Bandyopadhyay, 1992). The conclusions of Hettige et al. (1992), Cropper and Griffiths (1994), Selden and Song (1994) and Grossman and Krueger (1995) are consistent with the EKC hypothesis. Martinez-Zarzoso and Bengochea-Morancho (2004) find evidence that CO₂

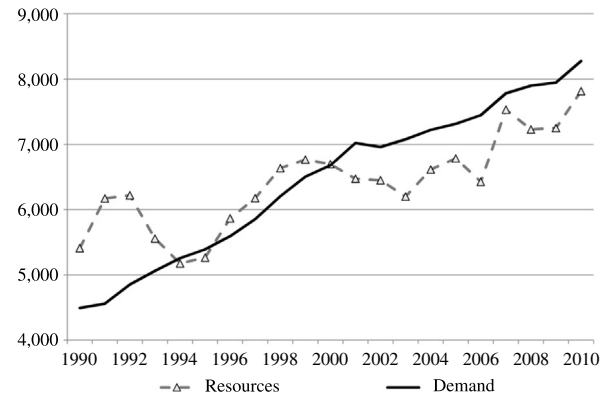


Fig. 1. National resources and domestic demand for primary energy in Tunisia, 1990–2010.
Source: Compiled by the authors based on data from Tunisia, National Agency for Energy Conservation (ANME), *The National Agency for Energy Conservation Report*, 3rd edition (Tunis, Tunisia: ANME, June 2011).

emissions and national income are negatively related at low income levels, but positively related at high-income levels. However, increased national income level does not necessarily warrant greater efforts to contain the emissions of pollutants. The empirical results of Shafik (1994) and Holtz-Eakin and Selden (1995) show that pollutant emissions are monotonically increasing with income levels. The existing literature reveals that empirical findings differ substantially and are not conclusive to present policy recommendation that can be applied across countries. In addition, few studies focus to test the nexus of output–energy and output–environmental degradation under the same integrated framework. Given that energy consumption has a direct impact on the level of environmental pollution, the above discussion highlights the importance of linking these two strands of literatures together (Ang, 2007 and 2008). Consequently, to avoid problems of misspecification, these two hypotheses must be tested under the same framework. This study for the case of Tunisian economy tries overcoming the shortcoming literature related with the linkage between economic growth, energy consumption and pollutant emissions under the same integrated framework, following the idea of Ang (2007 and 2008). Tunisia appears to be an interesting case study given that it is one of the highest growth economies in Middle East and North Africa region and energy supply in this country is insufficient to meet the increasing demand. Also, this empirical country study may be useful to formulate policy recommendation from the point of view of energy conservation, emission reduction and economic performance.

3. Tunisian economic and energy situations

The Energy and Environmental Situation in Tunisia: Tunisia is a country with limited natural resources confronted not only with continually increasing domestic energy demand but also with geopolitical and geo-economic upheavals that this sector has experienced. The energy sector is strategic and indispensable to Tunisian socioeconomic development, where the energy balance has started to show a deficit after having maintained a surplus for a period of four decades. Fig. 1 shows the trend of Tunisian demand outstripping resource supply. According to predictions, Tunisia's energy needs will continue to increase at a steady pace, which can be partially explained by the improvement in citizens' standard of living, whereas the national production is decreasing, which means that any durable development in Tunisia should rely, in the years to come, on new growth sources.

Fig. 2 provides an overview of Tunisia's greenhouse gas emissions by source; it highlights that the energy sector is the

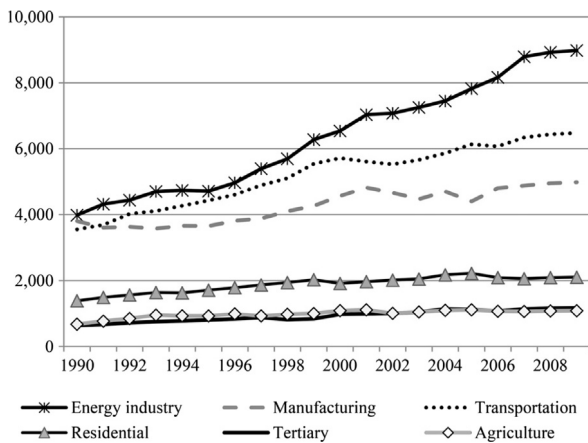


Fig. 2. Sources of greenhouse gas emission in Tunisia, 1990–2009.

Source: Compiled by the authors based on data from Tunisia, National Agency for Energy Conservation (ANME), *The National Agency for Energy Conservation Report*, 3rd edition (Tunis, Tunisia: ANME, June 2011).

largest, man-made contributor to greenhouse gas emissions. As a developing country, Tunisia is not committed to a reduction of greenhouse gas emissions as stipulated by the Kyoto Protocol, but it is alarming to see that the level of per-capita carbon dioxide emissions has increased dramatically over time.

The relationship between energy consumption and economic growth, as well as economic growth and environmental pollution, has been one of the most widely investigated topics in the economic literature during the three last decades. However, existing outcomes have varied considerably. Whether energy consumption stimulates, delays or is neutral to economic activities has motivated curiosity and interest among economists and policy analysts to find out the direction of causality between energy consumption and economic variables. The pioneering study by Kraft and Kraft (1978) found a unidirectional Granger causality running from output to energy consumption for the United States using data for the 1947–1974 time frame. The empirical outcomes of the subsequent studies on this subject, which differ in terms of time period, country, econometric techniques, and proxy variables, have reported mixed results and are not conclusive to offer policy recommendations that can be applied across countries. Depending upon the direction of causality, the policy implications can be considerable with regards to energy conservation, emission reduction and economic performance viewpoints. Most of the analyses on this topic have recently been conducted using Vector Autoregression (VAR) models. Earlier empirical works have used Granger (1969) or Sims (1972) tests to test whether energy use causes economic growth or whether energy use is determined by the level of output. 1. Their empirical findings are generally inconclusive. But when significant results are obtained, they indicate that causality runs from output to energy use. Erol and Yu (1987) tested the data of six industrialized countries and found some indications of a causal relationship between energy and output in a number of industrialized countries with the most significant relationship being for Japanese data between 1950 and 1982. However, when the sample was restricted to 1950–1973, the relationship was no longer significant. Yu and Choi (1985) also found a causal relationship running from energy to GDP in the Philippines economy, but causality is reversed in the case of South Korea. Ebohon (1996) examines the causal directions between energy consumption and economic growth for two African economies (Nigeria and Tanzania). The results show a simultaneous causal relationship between energy and economic growth for both countries. With advances in time series econometric techniques, more recent studies have focused on

the vector error correction model (VECM) and the cointegration approach. Masih and Masih (1996) used cointegration analysis to study this relationship in a group of six Asian countries and found that cointegration does exist between energy use and GDP in India, Pakistan, and Indonesia. No cointegration is found in the case of Malaysia, Singapore and the Philippines. The flow of causality is found to be running from energy to GDP in India and from GDP to energy in Pakistan and Indonesia. Using trivariate approach based on demand functions, Asafu-Adjaye (2000a,b) tested the causal relationship between energy use and income in four Asian countries using cointegration and error-correction analysis. He found that causality runs from energy to income in India and Indonesia, and a bi-directional causality in Thailand and the Philippines. Stern (2000) undertakes a cointegration analysis to conclude that energy is a limiting factor for growth, as a reduction in energy supply tends to reduce output. Yang (2000a,b) considers the causal relationship between different types of energy consumption and GDP in Taiwan for the period 1954–1997. Using different types of energy consumption, he found a bi-directional. See for example, Akarca and Long (1980a,b) and Yu and Hwang (1984). 4 causality between energy and GDP. This result contradicts with Cheng and Lai (1997a,b) who found that there is a unidirectional causal relationship from GDP to energy use in Taiwan. Soytaş and Sari (2003) discovered bi-directional causality in Argentina, causality running from GDP to energy consumption in Italy and Korea, and from energy consumption to GDP in Turkey, France, Germany and Japan. Paul and Bhattacharya (2004a,b) found bi-directional causality between energy consumption and economic growth in India. The empirical results by Oh and Lee (2004) for the case of Korea suggested the existence of a long-run bidirectional causal relationship between energy and GDP, and short-run unidirectional causality running from energy to GDP using VECM. Based on a production function approach, Ghali and El-Sakka (2004), develop a VECM model to test the existence and direction of causality between output growth and energy use in Canada. Their empirical findings indicate that the long-run movements of output, labor, capital and energy use in Canada are related by two cointegrating vectors and the short-run dynamics of the variables indicate that Granger-causality is running in both directions between output growth and energy use. Wolde-Rufael (2005) investigated the long run and causal relationship between real GDP per capita and energy use per capita for 19 African countries for the period 1971–2001. This work provides evidence of a long run relationship between energy consumption and economic growth for only eight of the 19 countries and a causal relationship for only 10 countries. Using cointegration analysis, Wietze and Van Montfort (2007) showed that energy consumption and GDP are cointegrated in Turkey over the period 1970–2003 and found a unidirectional causality running from GDP to energy consumption indicating that energy saving would not have a negative impact on economic growth in Turkey. On the other hand, the relationship between output growth and pollution level has also been well discussed in the literature of Environmental Kuznets Curve (EKC) where environmental degradation initially increases with the level of per capita income, reaches a turning point, and then declines with further increases in per capita income (Grossman and Krueger, 1991a,b). 2. Whether continued increase in national income brings more degradation to the environment is critical for the design of development strategies for an economy (Ang, 2007). Hence, a number of studies have attempted to assess the tie and to test for linear, as well as quadratic and cubic relationships between per capita income and CO₂ emissions. These studies deal with environmental degradation measure(s) as the dependent variable(s) and income as the independent variable and provide mixed results. On the other hand, there are several studies that realize the problem of omitted variables

bias and therefore include different explanatory variables ranging from macroeconomic variables such as prices, population, income distribution and trade balances to education, technology, and human development indicators (Soytas et al. 2007). Including labor and gross fixed capital formation in their model, (Soytas et al. 2007) examined the effect of energy consumption and output on carbon emissions in the United States and explored the Granger 2 Antweiler et al. (2001) and Coxhead (2003) postulate that this non-linear relationship between environmental pollution and income levels can be explained by three factors: scale, composition, and technique effects. The scale effect occurs as pollution increases with the size of the economy. The composition effect refers to the change in the production structure of an economy from agriculture-based to industry and service-based which results in the reallocation of resources. Finally, the pollution-income relationship also depends on techniques of production. An improvement in techniques of production, i.e., the technique effect, may reduce the amount of pollutant emissions per unit of production. 3. For a review of the Environmental Kuznets Curve research see for example the works of Stagl (1999), Yandle et al. (2002), Dinda (2004) and Stern (2004). 5 causality relationship between income, energy consumption, and carbon emissions. They found that income does not Granger-cause carbon emissions in the US in the long run, but energy use does. Hence, income growth by itself may not become a solution to environmental problems. The existing literature reveals that empirical finding studies differ substantially and are not conclusive enough to offer policy recommendations that can be applied across countries. In addition, few studies focus on testing the nexus of output–energy and output–environmental degradation under the same integrated framework. Ang (2007 and 2008) attempted to investigate dynamic causal relationships between pollutant emissions, energy consumption, and output using cointegration and vector error-correction modeling techniques. Considering annual data for France for the period 1960–2000, Ang (2007) provided empirical evidence of the existence of a fairly robust long-run relationship between these variables. His causality results support the argument that economic growth exerts a causal influence on growth of energy use and growth of pollution in the long run. His results also point to a unidirectional causality running from growth of energy use to output growth in the short-run. In his other empirical work, Ang (2008) examined the relationship between output, pollutant emissions, and energy consumption in Malaysia during the period 1971–1999. His empirical results provide support for a robust long-run equilibrium relationship between the variables, indicating that carbon emissions and energy use are positively related to output in the long-run. The causality results support the argument that economic growth exerts a positive causal influence on energy consumption growth, both in the short-run as well as the long-run. The results also provide some support for a feedback relationship in the long-run. With regards to the output–pollution link, only a weak causality running from CO₂ emissions growth to economic growth was found in the long-run. Following the idea of Ang (2007 and 2008) and given that energy consumption has a direct impact on the level of environmental pollution; the above discussion highlights the importance of linking these two strands of literatures together. The aim of this country specific study is to understand long and short-run linkages between economic growth, energy consumption and carbon emission using Tunisian data. These linkages were largely under considered and unanswered for policy makers in Tunisia and this empirical research attempts to present some findings to better integrate the environment into economic development decisions. Also, this case study for the Tunisian economy attempts to overcome the shortcomings in literature related with these linkages in developing economies. Tunisia is an interesting case

study given that it is one of the highest growth economies in the MENA region and energy supply in this country is insufficient to meet the increasing demand. This research may be useful to formulate policy recommendations from conservation, emission reduction and economic performance viewpoints. Conclusions for Tunisia may be applied to several countries, which have to go through a similar development path, increasing the pressure of the current energy resources scarcity. In fact, having a better view on the longrun equilibrium relationships and the short-run dynamics between GDP, energy consumption, Without applying the cointegration techniques, Sari and Soytaş (2007) explore the inter-temporal link between energy consumption and income in six developing countries, namely, Indonesia, Iran, Malaysia, Pakistan, Singapore, and Tunisia, within a multivariate framework that incorporates labor and capital as in a production function. These authors employ the generalized variance decompositions and generalized impulse response techniques to see if the growth of income and energy consumption contains considerable information to predict each other. In all countries, energy appears as an essential factor of production. Results indicate that energy may be a relatively more important input than labor and/or capital in some countries.

4. Conclusion

The aim of this country specific study is to understand long and short-run linkages between economic growth, energy consumption and CO₂ emission using Tunisian data over the period 1971–2004. Statistical findings indicate that economic growth, energy consumption and CO₂ emission are related in the long-run and provide some evidence of inefficient use of energy in Tunisia, since environmental pressure tends to rise faster than economic growth. In the short run, results support the argument that economic growth exerts a positive “causal” influence on energy consumption growth. In addition, results from impulse response do not confirm the hypothesis that an increase in pollution level induces economic expansion. Although Tunisia has no commitment to reduce Greenhouse Gas emissions, energy efficiency investments and emission reduction policies will not hurt economic activities and can be a feasible policy tool for Tunisia.

The aim of this country specific study is to understand long and short-run linkages between economic growth, energy consumption and CO₂ emission using Tunisian data over the period 1971–2004. Statistical findings indicate that economic growth, energy consumption and CO₂ emission are related in the long-run and provide some evidence of inefficient use of energy in Tunisia, since environmental pressure tends to rise faster than economic growth. In the short run, results support the argument that economic growth exerts a positive “causal” influence on energy consumption growth. In addition, results from impulse response do not confirm the hypothesis that an increase in pollution level induces economic expansion. Although Tunisia has no commitment to reduce Greenhouse Gas emissions, energy efficiency investments and emission reduction policies will not hurt economic activities and can be a feasible policy tool for Tunisia.

Hence, neutrality of energy does not seem to hold. 6 and CO₂ emissions in Tunisia may provide an answer to the question: to which extent can economic development be sustained under various energy supply constraints and pollution scenarios?

With its annual GDP growth rate exceeding 5% since 1995, Tunisia is among North African countries with the strongest growth potential. The improvement in Tunisian major macroeconomic indicators is the result of a series of economic reforms and prudent macroeconomic management (principally since the adoption and implementation of the structural adjustment program). The Tunisian economy is now diversified and less vulnerable than

in the past to external shocks such as climate hazards. Agriculture accounted for 12% of GDP in 2006. The manufacturing sector accounted for more than 60% of industrial production, about 20% of the working population and 18.2% of GDP. The services sector represents about 40% of GDP and half of the working population. It has expanded significantly in the past few years and has driven Tunisian growth upwards. At the sectoral level, growth in the last years was driven by strong domestic and European demand. It was primarily stimulated by services (telecommunications in particular), machinery and electricity industries, and construction and civil engineering. Over the years, the manufacturing and tourist sectors have gained a few percentage points of GDP to the detriment of the primary sector (agriculture, oil and phosphates). In Tunisia, demand for energy, notably electricity, has risen sharply during the last years. Household consumption has been the main engine of growth; it represented 63.8% of GDP in 2006 (up 8.8% from 2005). The increase of total primary energy consumption for the 1990–2005 period was very strong due to the rapid economic growth caused by increased tourism, transportation and industrial activities, as well as the increase in the standard of living of the Tunisian population.

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