Towards Sustainable Energy: What Have Natural Resource Extraction, Political Regime and Urbanization Got to Do With it?

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Although the importance of energy cannot be overemphasized, the increasing consumption has sustainable implications. Tunisia's energy consumption in recent times has exceeded supply raising concerns for future energy security. However, the country's energy intensity has been reducing for close to two decades. The study was embarked upon to investigate the drivers of Tunisia's total energy consumption and energy intensity. Estimation results from the fully modified OLS using annual time series data from 1971-2014 indicate that income, forest extraction, oil extraction and urbanization have positive effects on total energy consumption while mineral extraction and political regime negatively affect total energy consumption. However, income, political regime, urbanization and mineral extraction were all found to reduce energy intensity. Further asymmetric analysis showed that the parameters have been influenced by a structural effect. The policy implications of the findings include the need for the government of Tunisia to encourage investment activities on research and development to deepen the formulation of an improved energy savings technology to meet the rising demand for energy in the urban areas.

Keywords: *Tunisia, natural resource, energy consumption, energy intensity; asymmetric effects*

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Nomenclature

Abbreviations

EAP	Economic adjustment programme
FMOLS	Fully Modified Ordinary Least Squares
GDP	Gross Domestic Product
Mtoe	Million tonnes of oil equivalent
PP	Phillips-Perron
STIRPAT	Stochastic Impacts Regression on Population, Affluence and Technology
TWh	Terawatt hours
US$	United States of American Dollars
ZA	Zivot and Andrews

Variables

D	A slope dummy
EN	Energy usage
ENER	Total energy consumption
ENEIN	Energy intensity
URB	Urbanization
YPC	Income
TO	Trade openness
FOR	Forest extraction
OIL	Oil extraction
MIN	Mineral extraction
POLI	Political regime
lnEN	natural log of energy usage
lnENER	natural log of total energy consumption
lnENEIN	natural log of energy intensity
lnURB	natural log of urbanization
lnYPC	natural log of income
lnTO	natural log of trade openness
lnFOR	natural log of forest extraction
lnOil	natural log of oil extraction
lnMIN	natural log of mineral extraction
I(0)	integrated of the order zero
I(1)	integrated of the order one

Parameters

c_t , $\beta_{1,\dots}\ \beta_7$	parameters of explanatory variables

$\alpha_1, \alpha_2, ...\alpha_7$ parameters of interactive terms (variables)

1. Introduction

The literature on energy indicates that the energy sector plays an important role in the process of economic growth and development. However, the increasing level of energy consumption has been associated with sustainable growth and development challenges [1]. In the first place, for many developing countries, the rising energy consumption has exceeded production creating energy security issues. Secondly, energy usage has implications on changes in the climate, and thirdly, the rising energy consumption has health impacts on local air and water pollution. These energy consumption related issues have led to a renewed interest among researchers and policymakers to identify the factors that influence the level of energy consumption. Empirical studies to appreciate the causes of energy consumption, therefore, at the national level, abound [2-6]. Nonetheless, the results have been far from conclusive because different socio-economic factors have been identified to exert different effects on energy consumption. This leaves room for further empirical studies. Consequently, the present study aims at identifying the drivers of energy usage (consumption and intensity) in Tunisia.

Many developing countries have low access to energy. For instance, in Africa, 60% of the population does not have access to power supply. The situation worsens for sub-Saharan Africa where 68% of the population is without power [7]. Countries like Guinea, Ethiopia and Nigeria in the sub-region have 12%, 27% and 56% of the population respectively having access to electricity [8]. Few countries on the continent including Tunisia have a better story to tell with 100 percent of the population having access to electricity. Despite the 100 percent electricity access in Tunisia, a 5% annual increase in energy consumption over the past ten years has had a drain on the country's energy resources [9]. As a result, primary energy resources have seen a 6% annual reduction from 7.8 Million tonnes of oil equivalent (Mtoe) in 2010 to 5.4 Mtoe in 2016 [10]. Until 2000, Tunisia was a net exporter of energy as the country's energy production exceeded demand [11]. Since 2000 however, the increasing trend in energy demand has outgrown domestic production making it crucial for the country to import from other countries [10].

Projected figures suggest there will be a future rise in energy consumption for Tunisia. For instance, electricity consumption is expected to grow from its 2010 figure of 14 Terawatt hours (TWh) to 25-33 TWh by 2030 [12]. The implication is pressure will mount on the already stressed natural gas and oil used to produce about 95% of the country's current electricity but meets about 85% of its current domestic primary energy needs [12]. Thus, the country's energy import is expected to increase which has its own ramifications [4]. There is however another twist to the energy situation in Tunisia. While the country has witnessed rising energy demand against inadequate supply, there has been a significant drop in its energy intensity for almost two decades. This makes Tunisia one of the few countries in Africa to have lower energy intensity which signifies to some extent a high level of energy efficiency. This situation may promote market competitiveness, save energy cost, create low carbon economy and improve clean energy access [13] for the country. A World Bank analysis shows that Tunisia's energy intensity (a surrogate for measuring energy efficiency [14-16]) saw a reduction in the compound annual growth rate from -0.73 percent for the 1990-2000 to -1.13 percent for the 2000-2010 period, and between 2010-2012, there was a further reduction to -2.77 per cent [17]. With these developments, the obvious question that comes to mind is what might have contributed to this?

An answer to this question is essential for three main reasons. First is to help proffer to policymakers, a well-informed strategy to help manage the country's energy consumption to ensure future security. Secondly, it will also help to reduce the country's vulnerability to the incidence associated with energy (fossil fuel) importing countries. Thirdly, it will help unravel how energy consumption factors may also affect energy intensity. To answer the research question therefore, this paper empirically examines the drivers of total energy consumption and intensity in Tunisia. Empirical studies on Tunisia's energy situation are growing yet, they remain comparatively scarce. For instance, Abdallah et al., [18] assessed the drivers of energy demand in Tunisia's transport sector; Brand and Missaoui [12] analysed the electricity generation mix for Tunisia, Belloumi [19] and Arouri et al., [20] examined the causal relationship between energy consumption and income while Chitioui [21] investigated the link between energy consumption, financial development and growth in Tunisia. Also, Hammamia et al., [9] analysed Tunisia's energy intensity and Achour and Belloumi [22] investigated the energy consumption of the country's transport sector.

Nevertheless, there is still the need for further studies since the drivers of total energy intensity for Tunisia remain largely unexplored. Indeed, the majority of the existing studies have not offered enough evidence to unravel the different effect the driving forces of energy consumption may have on energy intensity. Further, none of the above studies has analysed the role political regime, natural resource extraction and urbanization play in Tunisia's energy consumption and intensity. A sound democratic system is largely regarded to help ensure efficiency in economic resource. Thus, dictatorship, unlike democracy, can lead to inefficient energy usage since citizens are denied the freedom to express their views and demand for efficiency [23]. Following the 1987 Coup D'etat, Tunisia witnessed a stabilized multi-party democracy although characterized by some level of autocracy, until 2011 when persistent anti-government protests forced the then President to flee the country and another elected. With this political system and climate Tunisia has experienced over the years, it is essential to analyse how this has affected energy usage.

Tunisia's population pressure evidenced by urban population growth has increased over the years. According to the World Development Indicators (WDI) [24], the country's total population (urban population) has jumped from 5,172,691 (2,291,761) in 1971 to 6,545,024 (3,348,696) in 1981, to 9,785,701 (6,245,039) in 2001 and then to 10,761,467 (7,113,330) in 2011. The WDI [24] data continues to reveal that since 1980 when Tunisia became more urbanized, the share of the urban population has increased from 50.569% to 65.934% in 2010. Kwakwa and Adu [25] among others have argued that rising urbanization has implications for energy consumption because of the presence of heavy vehicular movement and industrial activities that rely on energy. However, a review of works by Elliot et al., [1] and Sadorsky [26] indicates that the concentration of economic activities in urban areas promotes economies of scale which may lead to efficiency in energy usage. Thus, with the rising urbanization as against rising energy consumption but falling energy intensity in the country, it is necessary to ascertain the role of urbanization in this development to aid policymaking.

Parekh and Singh [27] have contended that the extraction and transformation of the natural resource is a major consumer of energy. A 2013 report by the International Energy Agency (IEA) indicates that 6.9% of the total energy (Mtoe) produced by the oil and gas industry was consumed by the same industry [27]. Tunisia is endowed with natural resources such as phosphates, petroleum, zinc, lead and iron ore. It is the world's fifth-leading producer of phosphate but places second in Africa [28]. According to the United States Energy Information Administration, Tunisia has shale formations with an estimated 23 trillion cubic feet of recoverable gas and 1.5 billion barrels of recoverable oil. It also produces about 60,000 barrels of oil per day and 6 billion cubic feet of natural gas [29]. Over the years, the contribution of the natural resource to the country's GDP although small, remains very significant. The WDI [24] illustrates that between 2010 and 2014 the share of oil rent to Gross Domestic Product (GDP) has been between 3.2% and 5.3%. Minerals rents as a share of GDP has also ranged between 0.42% and 1.21% while that of forest rent has been between 0.16% and 0.37%. The above makes it worthwhile to estimate the possible effect of natural resource extraction on the country's energy usage.

By estimating the effect of natural resource extraction, urbanization and political regime on energy consumption and intensity for Tunisia, the present paper becomes the first to do so for the country. It also contributes to the energy literature since previous studies on energy intensity including Adom and Kwakwa [13], Adom [14-15], and Chontanawat et al., [30] have excluded the effect of natural resource extraction. The current study acknowledges that Kwakwa et al., [4] have analyzed the effect of natural resources on Ghana's energy consumption. However, their study used total natural resource rent in the estimation process. In order to deepen our understanding, the present paper disaggregates natural resource rent into oil, minerals and forestry to examine the contribution of each of these sectors to the energy usage in Tunisia. Furthermore, following the assertion of Lucas [31] that policy regime changes render parameters non constant, as well as the subsequent empirical works of Terasvirta and Anderson [32], Stock and Watson [33] and Phillips [34] which indicated time-invariant models are inherently vulnerable to structural changes in the economy, the present study incorporates key structural change Tunisia has witnessed in the estimation process.

In 1986 Tunisia embarked upon economic adjustment programme (EAP) to address its poor economic performances. The effect of the programme was the increased economic growth, trade openness, privatization and political stability among others. Accordingly, the paper also assesses the influence periods before and after the EAP have on drivers of energy consumption and energy intensity. The rest of the paper is organized as follows: section two reviews relevant literature, section three describes the data and method used, section four explains and discusses the result of the study, and section five concludes and makes policy recommendations.

2. Literature review

Since the 1970s when energy was found to be critical to economic growth, policymakers and governments have responded by working towards adequate supply. However, since demand for energy has been rising beyond the production capacity, efforts have been made in the literature to explore the drivers of energy consumption or the relationship between energy and socio-economic variables at the national level in order to work towards sustainable energy. In Africa where energy poverty is relatively high, such studies are limited. At the national level and for a while, studies on the factors of energy consumption have examined specific energy type [35-39; 41-42]; or aggregate energy consumption [2-4].

Attention, however, in recent times has been given to the drivers of energy intensity by researchers such as Belloumi and Alshehry [82], Salim et al., [41], Shi [80], Adom and Kwakwa [13], Adom [14-16], Li and Lin [43] and Poumanyvong and Kameko [44]. Such attention is warranted since many studies that have analyzed forces of rising energy usage do not capture the efficiency associated with energy usage with respect to economic activities. To assess energy efficiency in the literature, energy intensity has been largely used as a surrogate. Thus, once the causes of the trends of energy intensity have been identified, it helps to offer effective demand-side management policies to achieve among other things environmental and energy security targets. The existing literature shows that a number of factors determine the level of energy consumption and intensity of which income, trade openness and urbanization are among the prominent ones.

2.1. Trade openness and energy consumption/intensity

Many arguments exist on the effect of trade openness on energy consumption and intensity. For instance, according to Grossman and Helpman [45], countries are able to imitate and learn from outsiders regarding their efficient use of energy through trade openness. Holmes and Schmitz [79] posited local firms are compelled to adopt efficient energy technology in order to compete favourably with foreign firms. Others, including Hubler [46] and Sbia et al. [47] are of the view that trade openness enhances domestic expenditure on research and development geared towards the promotion of energy efficiency. In his opinion, Cole [48] suggested that trade openness can increase or reduce energy intensity depending on the relative effects imports and exports have on energy intensity which is similar to the view documented by Sadorsky [49]. According to Sadorsky [49] trade can increase energy usage by making it easier for countries to import automobiles and other gadgets that rely heavily on energy. Again, trade can increase energy usage via the manufacturing and transportation of goods for export; as well as the transportation of imported goods to other parts of the country. However, when highly efficient equipment that consume less energy are made available to individuals and firms, trade can reduce energy consumption.

Empirical studies on trade effect have reported mixed outcomes. For instance, Hubler [46], Sbia et al., [47], Salim et al., [41] and Adom [14] reported that trade openness reduces energy intensity for China, UAE, Asian developing economies and South Africa respectively. However, Aboagye [5] reported trade openness reduces energy intensity in the short run but in the long run its effect is insignificant for Ghana. Kander et al. [50] also recorded an inverted U-shape curve between trade and energy intensity for European countries. On total energy consumption, Najarzadeh et al., [51] reported that export and import respectively have a positive and negative influence on the energy consumption for the Organization of Petroleum Exporting Countries (OPEC). Keho [2] recorded that imports increase Benin's, Ghana's and Senegal's energy consumption but reduce it for Togo and Cameroun.

2.2. Urbanization and energy consumption/intensity

Urbanization may affect the level of energy usage in diverse ways as documented by Sadorsky [52]. In the first place, urbanization increases energy usage through the creation of heavy motor traffic. However, the presence of mass transit infrastructure may reduce energy usage. Second, urbanization pressure increases the demand for additional infrastructure which without energy cannot be put up. Also, since urbanization is associated with economic development, demand for energy-intensive gadgets may increase energy usage. On the other hand, with individuals becoming wealthier through the economic prospect in urban areas, they may be in a position to acquire energy efficient gadgets which may reduce energy intensity. Further, the economies of scale associated with urbanization can help reduce energy intensity. Empirical results have also been mixed. Adom and Kwakwa [13] reported that urbanization increases Ghana's energy intensity; Belloumi and Alshehry [82] found urbanization increases energy intensity; while Salim et al., [41] indicated that urbanization reduces energy intensity. Also, Sadorsky [52] found urbanization has a mixed effect on energy intensity for developing countries. However, Aboagye [5] found no significant relationship between energy intensity and urbanization but a positive effect of urbanization on energy consumption. Li and Lin [43] have reported both positive and negative effect of urbanization on energy consumption depending on the stage of economic development for China.

2.3. Income and energy consumption/intensity

Another variable worth mentioning when it comes to energy consumption and intensity is the level of income. Bernardini and Galli [53] contended that increasing level of income will reduce energy usage. Their contention is that as an economy transforms through the stages of pre-industrialization, industrialization and post-industrialization the intensity of energy usage will eventually fall. During the pre-industrial stage (dominated by agriculture) energy intensity is low since basic needs drive economic growth. At the industrialization stage however, the need for infrastructural development to meet production and consumption increases energy intensity. Eventually, when the economy reaches the post-industrialized stage, service activities that are not energy intensive take over from manufacturing thereby reducing the energy intensity. They further argued that a high-income level is associated with technological advancement that can lead to lower energy intensity [26]. In addition, as income increases, citizens may be concerned with a quality environment and are therefore likely to reduce energy usage. On the other hand, Gertler et al., [54] have suggested that as income increases and individuals become richer their consumption pattern may change from lower to higher-energy dependent goods which may increase energy usage.

Empirically, Aboagye [5] obtained an inverted U-shaped relationship between income and energy consumption but a positive effect of income on energy intensity. Hubler and Keller [55] and Inglesi-Lotz and Morales [3] reported that income has a positive effect on energy for a group of developing countries and South Africa respectively. However, Wang and Han [56] reported a negative effect of income on China's energy intensity and Keho [65] also found that income reduces energy intensity in Cameroon, Congo DR, Cote d'Ivoire and Togo. Belloumi and Alshehry [82] and Salim et al., [41] also found income to reduce energy intensity.

2.4. Political regime and energy consumption/intensity

The role of quality institutions especially political regime to the management of economic resources has been well documented. However, the role of such institutions to ensuring energy security has been given little empirical attention. It is suggested that having a democratic type of government is likely to reduce inefficiency in the usage of resources than being under a dictatorship or autocratic rule. Panayoutou [57] and Gani [58] for instance have noted the role of government policies, political stability and government effectiveness among others towards the attainment of a quality environment of which energy consumption and efficiency is crucial. It is argued from the rational choice perspectives [23] that when countries are characterized by democratic rule, citizens have the chance to persuade and influence decisions that ensure efficient use of resource because of freedom of speech and voting. Moreover, democracy can help design appropriate policy to ensure resources are used efficiently. Also, in a democratic environment, there is a tendency to have the citizens well informed about environmental issues who will subsequently take the needed action to remedy the situation [59]. In the spirit of the above arguments, some researchers suggest that a higher quality of governance such as democratic governance reduces energy usage because of the stringent energy policies put in place [23, 60]. The opposite is the case when the economy is under a dictator who tends to increase resources depletion in order to reward loyal cronies and followers [78], and autocratic rule with the few elites, who are well informed than the public. In their empirical work, Cadoret and Padovana [60] found that political variables influence the decision to deploy renewable energy for European Union member countries. Specifically, they observed that quality of governance and government ideology increase the deployment of renewable energy while lobbies reduce deployment of renewable energy.

2.5. Natural resources and energy consumption/intensity

Comparatively, the effect of natural resources on energy consumption and intensity has not been given much attention in the literature although extractive processes require a lot of energy [42]. The heavy-duty machines to explore, extract and process natural resources are energy dependent. This suggests that the efficiency of the extractive activities tend to determine the extent of energy usage. Thus, if a natural resource-based industry is efficient its energy usage will be lower than when it is not efficient. There are very few documented empirical studies on the relationship between natural resource extraction and energy consumption. They include kayikçi and Bildirici [66] who found a unidirectional causality from oil rents to electricity consumption for Iraq and Saudi Arabia, and Kwakwa et al., [42] who also found a positive effect of natural resources rent on energy consumption for the Ghanaian economy.

2.6. Structural change and energy consumption/intensity

The above studies have assumed that the estimated parameters are constant over time. Meanwhile, Lucas [31] and others have argued that structural changes render parameters non-constant. Accordingly, asymmetric analysis of energy consumption has received some attention lately. Mention can be made of Adom and Bekoe [64] who reported significant changes in the parameters of electricity consumption drivers in Ghana. Adom and Kwakwa [13] also noted that economic reform program has significantly affected the effect of trade and manufacturing on energy intensity in Ghana. More so, Adom [14-16] have confirmed that the parameters of energy intensity factors for Nigeria, South Africa and Algeria have not been constant over time. In addition, Mikayilov et al., [81] realised that the income elasticity and price elasticity of electricity consumption in Azerbaijan vary over time; Chang et al. [67] found that the income effect on the demand for electricity in Korea is time-varying and Kwakwa [84] reported that structural changes affect the drivers of electricity consumption in Benin.

2.7. Conclusion of literature review

As it can be observed from the above, there is a substantial empirical literature on the drivers of energy consumption and intensity. Nevertheless, the results have been inconclusive. Further, the effect of institutional quality on energy consumption and intensity, as well as the role of natural resource extraction particularly mining, forestry and oil has on energy usage have not been given much attention.

With comparatively fewer empirical studies on Tunisia, this study thus attempts to analyze the energy consumption and intensity effect of natural resources extraction, political regime and urbanization in Tunisia. The effect of structural changes on the parameters is also analyzed.

3. Methodology

This section deals with the methodological issues of the study under sub sections of Theoretical and empirical specification, Estimation Strategy, and Data source and description.

3.1. Theoretical and empirical modeling

The theoretical framework for this study starts with the IPAT model. Ehrlich and Holdren [68] conceptualized the environmental impact of human and socio-economic factors through the *IPAT* model,

$$I=PAT \quad (1)$$

which contends that environmental impacts (I) is the product of population (P), affluence (A) and technology (T). Although the IPAT model attempts to unravel the effects of socio-economic activities on the environment it is criticized because its multiplicative nature does not reflect causal relationship and also it cannot consider non-monotonic or non-proportional effects of the variables [69]. To overcome these limitations Dietz and Rosa [70] and Dietz et al., [71] improved upon the IPAT model and developed a new model that allows for random errors in the estimation of the parameters. The new model which is the Stochastic Impacts Regression on Population, Affluence and Technology (STIRPAT) is given below:

$$I_t = C_t P_t^{\beta_1} A_t^{\beta_2} T_t^{\beta_3} \lambda_t \quad (2)$$

where *C* is a constant term, *βs* are the parameters to be estimated, λ is the stochastic term and *t* is the time period. Since higher energy usage is equivalent to poor environmental quality, the study represents the "I" with energy usage (EN). Also, urbanization (URB) is used to represent population pressure. Affluence is denoted by income (YPC). To capture technology which shows the efficiency in the transformation of inputs the study relies on the argument that trade openness enhances the transfer of advanced technology from the developed world towards emerging and developing economies [72], and previous studies [4] to represent technology with trade openness (TO).

Based on the argument and the evidence that extraction of natural resource involves a significant amount of energy consumption [4], and political regime can influence energy management [23], the STIRPAT equation (2) is modified to include forest extraction (FOR), oil extraction (OIL), mineral extraction (MIN) and political regime (POLI). The inclusion of these variables is worthwhile for the Tunisian case. With regards to the political regime, after the military intervention in 1987, the country enjoyed political stability until 2011 when the president was forced by anti-government protesters to flee the country and another elected. This shows how relatively the country has experienced political stability. However, its effect on energy consumption as argued in the literature has not been explored for the country. The inclusion of extraction of the natural resources is premised on the ground that the country is endowed with many natural resources that have contributed significantly to the country's economic growth and development. Since argument and evidence suggest such extraction may affect energy usage, it is critical to examine its effect for Tunisia. By taking into consideration the above-mentioned variables, equation (3)[1] below is derived:

$$EN_t = C_t URB_t^{\beta_1} YPC_t^{\beta_2} TO_t^{\beta_3} FOR_t^{\beta_4} OIL_t^{\beta_5} MIN_t^{\beta_6} e^{\beta_7 POLI_t} \lambda_t \quad (3)$$

Taking the natural log of each variable in Equation (3) gives equation (4) below:

$$\ln EN_t = c_t + \beta_1 \ln URB_t + \beta_2 \ln YPC_t + \beta_3 \ln TO_t + \beta_4 \ln FOR_t + \beta_5 \ln OIL_t + \beta_6 \ln MIN_t + \beta_7 POLI_t + \gamma_t \quad (4)$$

Where ln is natural log, c_t= lnCt, $\gamma_t = \ln\lambda_t$, *βs* are the parameters to be estimated, lnEN is the natural log of energy usage, lnURB is the natural log of urbanization, lnYPC is the natural log of income, lnTO is the natural log of trade openness, lnFOR is the natural log of forest extraction, lnOil is the natural log of oil extraction and lnMIN is the natural log of mineral extraction. Estimating equation (4) assumes that the parameters are constant over time. However, Lucas [31] among others have contended or/and demonstrated that structural breaks are likely to vary the parameters over time. It is essential to, therefore, to consider structural breaks to avoid misspecification of the model [15].

Consequently, the study goes on to do an asymmetric analysis of the drivers of energy usage by taking into consideration the effect of the structural change. The Chow breakpoint test confirmed 1986 as a structural breakpoint location. The year 1986 was when Tunisia embarked upon economic adjustment programme (EAP) to address its poor economic performances. Documentary evidence suggests the EAP has had some considerable effect on the country's economic growth, trade openness, privatization and political stability among others. As a result, following Adom [14-16] and Koutsoyiannis [83], a slope dummy (D) which takes the value of zero for the period prior to the economic adjustment programme in1986 and one for the remaining periods is created and multiplied by each of the regressors in equation (4) above to create interactive terms.

The interactive terms for each of the regressors are systematically added as additional regressors (i.e. Eqs. (5)-(11)). Differences in the coefficients of the interactive terms and their respective regressors indicate changes in slopes before and after the structural break and hence an indication of the significance of structural break to parameter non-constancy.

$$\ln EN = c_t + \beta_1 \ln URB_t + \alpha_1 D^* \ln URB + \beta_2 \ln YPC_t + \beta_3 \ln TO_t + \beta_4 \ln FOR_t + \beta_5 \ln OIL_t + \beta_6 \ln MIN_t + \beta_7 POLI_t + \gamma_t \quad (5)$$

$$\ln EN = c_t + \beta_1 \ln URB_t + \beta_2 \ln YPC_t + \alpha_2 D^* \ln YPC_t + \beta_3 \ln TO_t + \beta_4 \ln FOR_t + \beta_5 \ln OIL_t + \beta_6 \ln MIN_t + \beta_7 POLI_t + \gamma_t \quad (6)$$

$$\ln EN = c_t + \beta_1 \ln URB_t + \beta_2 \ln YPC_t + \beta_3 \ln TO_t + \alpha_3 D^* \ln TO_t + \beta_4 \ln FOR_t + \beta_5 \ln OIL_t + \beta_6 \ln MIN_t + \beta_7 POLI_t + \gamma_t \quad (7)$$

$$\ln EN = c_t + \beta_1 \ln URB_t + \beta_2 \ln YPC_t + \beta_3 \ln TO_t + \beta_4 \ln FOR_t + \alpha_4 D^* \ln FOR_t + \beta_5 \ln OIL_t + \beta_6 \ln MIN_t + \beta_7 POLI_t + \gamma_t \quad (8)$$

$$\ln EN = c_t + \beta_1 \ln URB_t + \beta_2 \ln YPC_t + \beta_3 \ln TO_t + \beta_4 \ln FOR_t + \beta_5 \ln OIL_t + \alpha_5 D^* \ln OIL_t + \beta_6 \ln MIN_t + \beta_7 POLI_t + \gamma_t \quad (9)$$

[1] When one takes the log of polity2 it generates missing data (because of the nature of the raw values) which would not be useful for any estimation. To avoid that, the acceptable theory and norm in empirical studies [see 86-87] was followed. Polity was expressed as natural exponential function ($e^{\beta 7POLI}$) so that the log of the natural exponential would give (β_7POLI) for estimation.

$$\ln EN = c_t + \beta_1 \ln URB_t + \beta_2 \ln YPC_t + \beta_3 \ln TO_t + \beta_4 \ln FOR_t + \beta_5 \ln OIL_t + \beta_6 \ln MIN_t + \alpha_6 D * \ln MIN_t + \beta_7 POLI_t + \gamma_t \quad \textbf{(10)}$$

$$\ln EN = c_t + \beta_1 \ln URB_t + \beta_2 \ln YPC_t + \beta_3 \ln TO_t + \beta_4 \ln FOR_t + \beta_5 \ln OIL_t + \beta_6 \ln MIN_t + \beta_7 POLI_t + \alpha_7 D * POLI_t + \gamma_t \quad \textbf{(11)}$$

3.2. Econometric Method

The empirical investigation starts by analyzing the stationarity of the variables in order to avoid having spurious regression results should the variables be non-stationary. This is examined by conducting the unit root test of the series. The study relied on the Phillips-Perron (PP) test to determine the stationarity of the variables. The Zivot and Andrews (ZA) unit root test which is capable of providing robust results in the presence of structural break is employed to complement the results of the PP test. After the stationarity of the variables has been confirmed, the long-run relationship among the variables using the Engel-Granger and Phillip-Ouliaris co-integration tests are examined. Then, the Phillips and Hansen [73] Fully Modified Ordinary Least Squares (FMOLS) co-integrating estimator is employed to examine the effects of population, urbanization, income, trade openness, natural resource extraction and political regime. The rationale for settling on the FMOLS is that it is more robust to the problems of serial correlation and endogeneity than other estimators.

3.3. Data description and source

This study uses annual time series data covering 1971-2013. The selection of this period is influenced by data availability. Two proxies, total energy consumption (ENER) and energy intensity (ENEIN) are used to measure energy usage which happens to be the dependent variable. This is based on earlier remarks in the introduction section. It is described in that section that although Tunisia has witnessed rising energy demand against inadequate supply, there has been a significant drop in its energy intensity for almost two decades. So, to understand the drivers of energy consumption and energy intensity, the two proxies, total energy consumption and energy intensity are used for energy usage. Total energy consumption is measured as Energy use (kilogram of oil equivalent) [24] while energy intensity is measured as the ratio of total energy consumption to gross domestic product [13].

Regarding the explanatory variables, urbanisation is measured as the share of the urban population (% total population); income is measured as GDP per capita (constant 2010 US$), and; trade is measured as the sum of import and export as a share of GDP [13]. Extraction of the forest resource, mineral resource and oil resource are respectively measured as forest rents (% of GDP), mineral rents (% of GDP) and Oil rents (% of GDP) [WDI 24]. Polity2 is used to denote political regime type and it varies from −10 to 10. Negative scores denote autocracy and positive values denote democracy [85]. Except Polity 2 that is sourced from Polity IV Project [85], the rest of the data is from the WDI [24] database.

Table 1 shows the summary descriptive statistics of the series. In summary, the Jarque-Bera test indicates that except political regime, oil rent, forest rent and mineral rent all the other variables are found to be normally distributed. Again, it is seen that all the series are positively skewed except urbanization and trade openness. The average energy consumption is 639.06 kg of oil equivalent with a standard deviation of 186.09 kg of oil equivalent. The mean per capita income is US$ 2612.719 and has a standard deviation of US$ 836.71. Also, urban population (% of total population) has a mean of 57.77% and a standard deviation of 7.12%. The mean values of natural resource rent (% of GDP) from forest, mining and oil is about 0.19%, 0.49% and 4.74% respectively and standard deviation of about 0.07%, 1.04% and 3.42% respective. The mean value of the polity 2 is -5.03 and a standard deviation of 3.65.

4. Results and discussion

This section discusses the results of the study under sub-sections stationary and co-integration test, structural test, long-run determinants of total energy consumption and energy intensity, and asymmetric analysis of the drivers of total energy consumption and energy intensity.

Table 1. Descriptive Statistics

	ENER	**ENEIN**	**YPC**	**URB**	**TO**
Mean	639.0637	3.12E-08	2612.719	57.77412	83.01530
Median	603.6105	3.05E-08	2387.671	59.56200	85.34166
Maximum	966.3344	4.56E-08	4196.752	66.45600	114.3548
Minimum	320.0771	2.05E-08	1356.581	44.30500	48.53609
Std. Dev.	186.0952	7.42E-09	836.7142	7.129375	15.02191
Skewness	0.128523	0.175560	0.582688	-0.392438	-0.347231
Kurtosis	1.930387	1.743879	2.107400	1.729283	2.938617
Jarque-Bera	2.168175	3.047852	3.860751	3.996765	0.870834
Probability	0.338210	0.217855	0.145094	0.135554	0.646995
Observations	43	43	43	43	43
	FOREST	**MIN**	**OIL**	**POLI**	
Mean	0.186410	0.489794	4.735022	-5.023256	
Median	0.178112	0.074185	4.079037	-5.000000	
Maximum	0.414227	4.885329	14.62113	6.000000	
Minimum	0.089152	0.006299	0.010873	-9.000000	
Std. Dev.	0.068910	1.044727	3.423069	3.654667	
Skewness	0.857959	3.057705	1.254872	1.173692	
Kurtosis	3.963302	11.64117	4.397500	4.730541	
Jarque-Bera	6.937911	200.7886	14.78450	15.23810	
Probability	0.031150	0.000000	0.000616	0.000491	
Observations	43	43	43	43	

4.1. Results for stationarity test and co-integration test

The results of the stationarity test have been reported in Table 2 below. From the PP test result, it is seen that at least one of the assumptions confirm all the variables to be stationary. Income, trade openness, mineral rent and total energy consumption become stationary at first difference rendering them *I(1)* variables, strictly speaking. Oil rent and polity2 are *I(0)* variables since they are stationary at levels under all the assumptions. The remaining variables are also found to be stationary but they are either *I(0)* or *I(1)* under the different assumptions. The results from the Zivot and Andrews (ZA) test also confirmed the variables are stationary. However, the ZA results have not been presented here for want of space (see Table A1 in supplementary file). The general indication is that all the variables are stationary either in levels or at first difference and that their usage in the estimation process will not lead to any spurious regression result.

The co-integration test carried out to determine whether long-term relationships exist among the variables employed the Engel-Granger and Phillip-Ouliaris test and the results are reported in Table 3. The results indicate there is a long-run relationship between total energy consumption on one side and income, trade openness, urban population, political regime and extraction of the natural resource, on the other side. A similar finding is observed for energy intensity on the one hand, and income, trade openness, urban population, political regime and extraction of the natural resource on the other side. This implies that income, trade openness, urbanization, political regime, oil extraction, mineral extraction and forest extraction are the long-run forcing variables explaining total energy consumption and energy intensity in Tunisia.

Table 2. PP Unit root test results

Variables	Constant		Constant & Trend		No Constant and Trend	
	Levels	First difference	Levels	First difference	Levels	First difference
lnYPC	-1.5767	-6.7395***	-2.8641	-6.7249***	-5.5613	-4.4654***
lnTO	-2.5723	-6.0448***	-2.7771	-6.1752***	1.5124	-5.8148***
lnURB	-5.0643**	NA	0.4665	-1.7280	6.3137	-1.7579*
lnFOR	-2.9452**	NA	-2.9466	-10.7689***	-0.3429	-10.6548**
lnMIN	-1.9127	-6.1849***	-1.8128	-6.9862***	-1.2851	-6.2635***
lnOIL	-3.7731**	NA	-4.3928***	NA	-2.3132**	NA
POLI	-3.7736***	NA	-4.3928***	NA	-2.3433***	NA
lnENER	-2.6481	-12.8531***	-3.1363	-10.7099***	5.1547	-8.0350***
lnENEIN	-2.6441	-19.5259***	-4.7777****	NA	-13.9951	-7.7133***

***, ** and * denote 1%, 5% and 10% level of significance, respectively. NA means Not Applicable

Table 3. Engel-Granger and Phillips-Ouliaris tests results for Co-integration

Series	Engel-Granger test		Phillips-Ouliaris test	
	tau-statistic	z-statistic	tau-statistic	z-statistic
lnENER: lnYPC, lnTO, lnURB, lnFOR, lnMIN, lnOIL, POLI	-8.1346***	-57.472***	-8.2214***	-52.0557***
lnENEIN: lnYPC, lnTO, lnURB, lnFOR, lnMIN, lnOIL, POLI	-8.7774***	-48.3771***	-8.4689***	-50.5507***

*** 1% level of significance

4.2. Structural break test

Since structural break affects the constancy of the parameters, the study tests for the presence structural break. The paper adopts the Chow breakpoint and the Chow forecast test to analyse the presence of structural break for the year 1986 (when Tunisia embarked upon economic adjustment programme (EAP) to address its poor economic performances). Both tests work with the null hypothesis of the presence of no breaks at specified breakpoints. The results of the Chow breakpoint as shown in Table 4 indicate that the null hypothesis of no breaks at the specified breakpoint (1986) is rejected by all the three test statistics for the regressors of total energy consumption and energy intensity. This means that the coefficients are not stable across time. The results are confirmed by the Chow Forecast test reported in Table 5.

4.3. Long-run determinants of total energy consumption and energy intensity

This section presents the main findings on the effects of income, trade openness, urbanization, natural resources extraction and political regime on total energy consumption and intensity in Tunisia for the 1971-2013 time period. The regression results presented in Table 6 show that income significantly affects total energy consumption and energy intensity for Tunisia over the study period. Specifically, it is seen that an increase in income increases total energy consumption but reduces energy intensity. The positive effect of income on energy consumption indicates that a 1% increase in income per capita will lead to about 0.79% increase in total energy consumption. Thus, as income increases, citizens in the economy become richer and are placed in a position to acquire intensive energy consuming equipment and as a result, energy consumption will increase. The findings from this study confirm previous works such as Sineviciene et al., [6] and Inglesi-Lotz and Morales [3]. However, a higher level of income tends to reduce energy intensity for Tunisia. Specifically, a 1% rise in income per capita will reduce energy intensity usage by 0.27%. The findings mean that although income increases total energy consumption, it has an overall reduction effect on energy intensity. This is an indication that energy productivity increases with income in Tunisia. In other words, the reduction effect of income on energy consumed for production outweighs the positive income effect on total energy consumption. The fact that the rise in income ensures lower energy intensity in Tunisia compares favourably with Belloumi and Alshehry [82] and Salim et al., [41].

The coefficient of trade openness is positive for both energy consumption and intensity. However, it is not statistically significant for the former. Thus, increasing trade openness although may exert some positive effect on energy consumption it is not significant enough. Regarding the effect of trade on energy intensity, however, it is found to exert significant positive effect such that a 1% increase in the level of trade openness will increase energy intensity by 0.09%. This shows that the increasing trend of Tunisia's trade openness from 47% of GDP in 1970 to 91% of GDP in 1991 and then to 114% of GDP in 2008 increased energy intensity. As argued in the literature, trade may increase energy usage since high energy consuming gadgets may be readily accessible; more goods have to be manufactured and transported for export; and also imported goods have to be transported to other parts of the country. On the other hand when trade openness enables efficient gadgets to be readily available; when trade leads to competition and transfer of technological knowledge; it may reduce energy intensity. The current result is in line with the former argument and also supports Aboagye [5]. While urbanization increases energy consumption, it has a negative effect on energy intensity. The results show that a 1% increase in the share of urban population to the total population will increase energy consumption by 0.46% but will reduce energy intensity by 1.29%. Of course, the effect of urbanization on energy usage as discussed in the literature is complicated since it can have both positive and negative effects. As Elliot et al., [1, page 4] put it in a concise manner:

"On the one hand, urbanization tends to increase demand for more energy-intensive products as urban residents rely much more on electrical appliances and modern transportation which implies a higher energy demand per person than those living in rural areas. On the other hand, the concentration of production and consumption in a relatively small geographical area should provide opportunities for economies of scale that can improve overall energy efficiency."

Table 4. Results for Chow Breakpoint Test, 1986

lnENER: lnYPC, lnTO, lnURB, lnFOR, lnMIN, lnOIL, POLI				
F-statistic	6.432432		Prob. F(7,29)	0.0001
Log likelihood ratio	40.29678		Prob. Chi-Square(7)	0.0000
Wald Statistic	45.02702		Prob. Chi-Square(7)	0.0000
lnENEIN: lnYPC, lnTO, lnURB, lnFOR, lnMIN, lnOIL, POLI				
F-statistic	55.57438		Prob. F(7,29)	0.0000
Log likelihood ratio	114.7341		Prob. Chi-Square(7)	0.0000
Wald Statistic	389.0206		Prob. Chi-Square(7)	0.0000

Table 5. Chow forecast results for observations from 1986 to 2013

lnENER: lnYPC, lnTO, lnURB, lnFOR, lnMIN, lnOIL, POLI				
	Value	df	Probability	
F-statistic	1.466105	(28, 8)	0.2966	
Likelihood ratio	77.97695	28	0.0000	
lnENEIN: lnYPC, lnTO, lnURB, lnFOR, lnMIN, lnOIL, POLI				
	Value	df	Probability	
F-statistic	9.081274	(28, 8)	0.0015	
Likelihood ratio	150.0680	28	0.0000	

Table 6. FMOLS results for long-run estimates

	Total energy consumption		Energy Intensity	
Variable	Coefficient	t- stats	Coefficient	t- stats
lnYPC	0.7959****	13.4175	-0.2711***	-5.2931
lnTO	0.0576	0.9677	0.0872*	1.700
lnFOR	0.0384**	2.5185	0.0090	0.6836
lnOIL	0.0112***	2.7596	0.0139***	3.9356
lnMIN	-0.0163***	-4.2156	-0.0171***	-5.1133
POLI	-0.0042*	-1.8302	-0.0051**	-2.5474
lnURB	0.4616**	2.5119	-1.2913***	-8.1389
CONSTANT	-1.9351***	-5.8459	-10.4120***	-36.4241
Adj. R^2	0.99		0.99	
DW-stat	1.96		2.21	

***, ** and * denote 1%, 5% and 10% level of significance, respectively

Judging from the above argument, the differences in the ambiguous results could be attributed to the fact that an increase in the urban population growth will lead to a rise in demand for energy. However, the urban dwellers become efficient in their energy consumption hence a reduction in the energy intensity. This is understandable since once a geographical area gets urbanized, the pressure on energy resources will be felt and identified easily, and as such efforts would be put in place to ensure efficiency in its usage. Further, the high cost in accessing energy in urban areas than rural areas could account for such a negative relationship between urbanization and energy intensity since urban population would want to be efficient in order not to increase their expenditure on energy. Then again, the fact that energy shortage badly affects urban areas more than rural areas, owing to the latter's heavy dependence on energy; it is possible that will compel urban dwellers to be efficient in their energy usage. Previous studies such as Salim et al., [41] and Sheng et al., [74] obtained a similar outcome.

The results go on to show that political regime measured by polity2 helps to reduce energy consumption and intensity in Tunisia. Specifically, an improved democracy by one unit will reduce total energy consumption by 0.004 units and energy intensity by 0.005units. The available literature points to the direction that democracy is very helpful in the reduction of energy usage [23, 60].

By enabling citizens to be informed about environmental issues; allowing citizens to share their views on energy issues and demand for accountability, democracy has over the study period led to a better utilization of energy in Tunisia. This also supports Cadoret and Padovana [60] and Mayer [23].

Focusing on natural resource variables, it is observed that extraction activities within the forestry sub-sector increase total energy consumption; extraction activities within the oil sub-sector increase total energy consumption and intensity, while the extraction activities within the mining sub-sector reduces total energy consumption and intensity. Measured by the rents, a 1% increase in the forestry rent will increase total energy by 0.03%. This observed positive relationship between forestry extractive activities and energy consumption in the country could be explained by the fact that the sub-sector is confronted by a number of challenges including lack of financial and technical resources, and a high incidence of poverty among rural and forest population [61]. In this case, extractors of the forest rely on obsolete technology for their activities which renders the sector inefficient. The oil sub-sector is seen to have a positive effect on energy consumption and intensity. This also suggests that the sub-sector has not been energy efficient over the study period. It is possible to argue that generally, the major international companies [75] that dominate the country's oil sector have not employed the most efficient production technology as they would in developed countries with stricter regulations on environment hence the positive effect of the extractive activities in the oil sub-sector on energy consumption and intensity. The opposite is the case of the mining sub-sector where its extractive activities reduce energy consumption and energy intensity. The positive effect of the extraction activities in the forestry and the oil sub-sectors is similar to the findings of Kwakwa et al., [42]. The values of the Durbin-Watson statistic and Adjusted R^2 indicate the results are reliable. Other diagnostic tests to ascertain the adequacy of the estimated equations confirmed the robustness of the models (see Figures A1 and A2, and; Tables A2 to A5 in supplementary file).

4.4. Asymmetric effects of the drivers of energy consumption and intensity

This section of the paper presents findings on the changing effects of income, trade openness, urbanization, natural resource extraction and political regime on total energy consumption and intensity in Tunisia. Tables 7 and 8 contain results of seven different estimations for the asymmetric effects of the drivers of energy consumption and intensity respectively. Model 1, in Table 7, shows the result for the asymmetry in income effect. The baseline income elasticity is positive and significant signalling that the effect of income on total energy consumption before the EAP in 1986 was positive. However, the post-1986 estimation shows that income has a negative effect on total energy consumption as indicated by the interactive income elasticity coefficient of -0.008.

The results reveal that the post-1986 effect of income on total energy consumption is negative and that a 1% increase in per capita income will reduce total energy consumption by 0.008% post-EAP. This result implies that the energy-saving effect of income is negative after the EAP. In Model 1 of Table 8, both income and income interactive term have significant negative effects on energy intensity. However, the post-1986 effect is more prominent as the coefficient of income post-EAP is -0.008. This implies energy-saving potentials of income post-1986 increases by - 0.008. A possible explanation to the changing effects of income on total energy consumption and intensity is that Tunisia's post-1986 period has witnessed an increased level of income per capita which has made it necessary for citizens to acquire energy efficient equipment or demand for a quality environment. Ayadi and Mattoussi [76] reported that, prior to the 1986 EAP, the country witnessed a slowdown in growth and productivity so much that between 1981 to 1986, the country saw its lowest growth performance (2.8 percent) and productivity decline (around 1.5 per cent per year) which reduced per capita income. However, after the 1986 EAP, per capita income has almost doubled from US$ 2082.131 in 1986 to US$ 4014.917 in 2011 [24]. With a rise in per capita income citizens can now afford energy efficient gadgets than before, hence the greater reduction effect of income on energy intensity and the reducing effect of income on total energy consumption. Adom [15] found the impact of income is not constant over time.

Regarding trade openness, Model 2 in Table 7 shows the baseline estimation recorded a positive but insignificant effect on total energy consumption. However, the trade interactive term shows a significant and negative effect on total energy consumption. This also indicates that the post-1986 trade openness effect on total energy consumption has been negative. On energy intensity, Model 2 in Table 8 reveals that trade effect prior to the 1986 EAP is positive (0.0794) and significant. However, the trade interactive term shows that the effect becomes negative (-0.0124) and significant after the 1986 EAP. Thus, the post-1986 EAP has helped trade to improve energy usage in Tunisia. This can be explained by the fact that prior to the 1986 EAP, trade was more restricted but after the mid-1990s, the authorities opened the country up to be part of the global competition which encouraged foreign direct investments. The post-1986 effect is that trade openness has helped the country to imitate and learn from outsiders regarding their efficient usage; local firms have been compelled to adopt efficient energy technology to compete with foreign firms and also energy efficient equipment have been made more accessible than before helping to reduce energy intensity. Studies by Shen [77] and Adom [15] have also shown that the trade openness parameter exhibits structural effect.

Model 3 shows the effect of forest extractive activities. For the total energy consumption, the baseline estimation is positive but insignificant while the post-1986 EAP effect is positive and significant (Table 7). A similar outcome is recorded for effect on energy intensity (Table 8). The post-EAP might have made available both energy-efficient and inefficient machines to operators in the forest industry through trade. However, since many of the operators in the forest industry are poor [61], they may resort to energy-intensive machines that are cheaper than energy-efficient machines. Model 4 in Table 7 shows that prior to the EAP, the extractive activities in the oil sub-sector increased total energy consumption. However, the post-EAP effect as indicated by the coefficient of the oil interactive term is significantly negative. A similar outcome is recorded in Table 8 regarding the effect of extractive activities in the oil sub-sector on energy intensity. This means that the oil-sub sector saves more energy post-EAP. This is an indication that there has been a shift from a more energy intensive methods of extracting oil to a less energy-intensive methods of oil extraction following the EAP in 1986. Regarding the mining sub-sector, Model 5 in Table 7 shows that prior to the 1986 EAP, mining activities reduced energy consumption but the effect become positive after the 1986 EAP. Model 5 in Table 8 also shows that the effect of the mining sub-sector on energy intensity prior to the 1986 EAP is negative and significant while the post-EAP is positive but insignificant. With an insignificant mining interactive term, it implies that the effect of mining sub-sector on energy saving has not been significantly affected by structural change. The post EAP effect of extraction from the forest and oil sub-sectors supports Lucas [31] while that of the mining sector contradicts Lucas [31].

Model 6 in Tables 7 and 8 captures the changing effect of political regime on total energy consumption and energy intensity respectively. The estimation for the total energy shows that periods before the EAP saw political regime reducing the level of energy consumption while after the EAP, political regime exerts a positive effect on energy consumption. A comparable effect is recorded for energy intensity estimation in Table 8 Model 6. This change in direction and magnitude of the political regime interactive term shows the importance of structural effects to changing parameters. The government of Tunisia has for a long-time subsidized energy consumption and attempts to remove it are among the reasons for the post-EAP political riots in the country. Consequently, government over the years has not had the political will to remove energy subsidies. Moreover, the post-EAP era has witnessed an increment in the level of subsidy from 4-6% of GDP in the early 2000s [62] to about 10% of GDP in 2013 [63]. Such action means citizens can have cheap access to energy and may not put conservation mechanism in place hence the rising level of energy usage.

In model 7, the pre-EAP urbanization effect on total energy consumption is positive while the post-EAP urbanization effect is negative. This also shows the importance of structural effects on parameters. For the pre-EAP period, an increase in the urban population as a share of the total population by 1% would lead to about 1.001% increase in the total energy consumption. However, the urban interactive term indicates a 1% increase in the share of the urban population will reduce total energy consumption by 0.0155%. Concerning energy intensity, Model 7 in Table 8 shows that urbanization for both the pre and post-EAP periods has statistically negative coefficients with energy intensity reduced further by 0.0132 for post-EAP period. This is an indication that the energy saved via urbanization improves after the EAP. The results clearly suggest the usage of energy efficient technologies by the urban population as well as the prevalence of intense economies of scale associated with urbanization post-EAP. The findings in this study tend to corroborate Adom and Bekoe [64].

Table 7. Asymmetric effects of determinants of energy consumption

	Total energy						
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
lnYPC	0.6825*** (10.8984)	0.6708*** (10.5528)	0.6860*** (10.6879)	0.7398*** (15.3582)	0.6895*** (9.2956)	0.7340*** (11.9145)	0.6750*** (10.4882)
D*lnYPC	-0.0080** (-2.5969)						
lnTO	0.0433 (0.8526)	0.0534 (1.0842)	0.0538 (1.0226)	0.0777 (1.6781)	0.0304 (0.5347)	0.0439 (0.7890)	0.0439 (0.8661)
D*lnTO		-0.0143** (-2.6807)					
lnFOR	0.0439*** (3.3452)	0.0435*** (3.3851)	0.0199 (1.3427)	0.0456*** (3.5187)	0.0262* (1.8018)	0.0438*** (3.0431)	0.0438*** (3.3386)
D*lnFOR			0.0456*** (2.7737)				
lnOIL	0.0078** (2.1467)	0.0073** (2.0566)	0.0052 (1.2968)	0.0089*** (2.7586)	0.0127*** (3.3668)	0.0101** (2.6420)	0.0078** (2.1669)
D*lnOIL				-0.0163** (-2.1876)			
lnMIN	-0.0125*** (-3.5484)	-0.0122** (-3.5132)	-0.0132*** (-3.7399)	-0.0137*** (-4.3166)	-0.0219*** (-5.1754)	-0.0142*** (-3.8966)	-0.0125*** (-3.5748)
D*lnMIN					0.0124** (2.1744)		
POLI	-0.0041** (-2.1293)	-0.0040** (-2.1305)	-0.0058*** (-2.7685)	-0.0041** (-2.3181)	-0.0034 (-1.6361)	-0.0067** (-2.6044)	-0.0041** (-2.1295)
D*POLI						0.0040* (1.8529)	
lnURB	0.9958*** (3.9458)	1.0100*** (4.0524)	1.0716*** (3.9600)	0.6536*** (4.0110)	0.7854*** (3.3951)	0.7342*** (3.3563)	1.0099** (3.9455)
D*lnURB							-0.0155** (-2.6087)
CONSTANT	-3.0839*** (-5.9110)	-3.0920*** (-6.0664)	-3.5010*** (6.7501)	-2.3285*** (-7.2970)	-2.3030*** (-6.5950)	-2.4827*** (-5.8747)	-3.5020*** (6.5017)
Adj. R^2 DW-Stat	0.99 2.08	0.99 2.08	0.99 2.12	0.99 1.98	0.99 2.03	0.99 1.93	0.99 2.08

***, ** and * denote 1%, 5% and 10% level of significance, respectively; t-statistics in parenthesis

Table 8. Asymmetric effects of determinants of energy intensity

	Energy intensity						
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
lnYPC	-0.3664*** (-6.4980)	-0.3776*** (-6.6014)	-0.3543*** (-6.2636)	-0.3253*** (-7.9446)	-0.3230*** (-4.7682)	-0.3347*** (-6.4160)	-0.3725*** (-6.4212)
D*lnYPC	-0.0068*** (-2.4569)						
lnTO	0.0712 (1.5570)	0.0794* (1.789)	0.0847* (1.8267)	0.1001** (2.5407)	0.0754 (1.4494)	0.0712 (1.5107)	0.0718 (1.5687)
D*lnTO		-0.0124** (-2.573)					
lnFOR	0.01425 (1.2055)	0.0140 (1.2154)	-0.0051 (-0.3884)	0.0188* (1.7099)	0.0022 (0.1721)	0.0147 (1.2117)	0.0142 (1.1970)
D*lnFOR			0.0345** (2.3872)				
lnOIL	0.0111*** (3.4185)	0.0107*** (3.3334)	0.0094** (2.6312)	0.0117*** (4.2626)	0.0148*** (4.2738)	0.0128*** (3.9839)	0.0112*** (3.4387)
D*lnOIL				-0.0180*** (-2.8446)			
lnMIN	-0.0137*** (-4.3452)	-0.0135*** (-4.3080)	-0.0147*** (-4.7288)	-0.0141*** (-5.220)	-0.0199*** (-5.1442)	-0.0149*** (-4.8238)	-0.0138*** (-4.3688)
D*lnMIN					0.0062 (1.1902)		
POLI	-0.0020*** (-2.8943)	-0.0049*** (-2.9191)	-0.0063*** (-3.3791)	-0.0052** (-3.4202)	-0.0047** (-2.4295)	-0.0078*** (-3.5855)	-0.0050*** (-2.8899)
D*POLI						0.0042** (2.2958)	
lnURB	-0.8326*** (-3.6641)	-0.8140*** (-3.6311)	-0.8296*** (-3.4779)	-1.0779*** (-7.7807)	-1.1347*** (-5.3692)	-1.0041*** (-5.4207)	-0.8220*** (-3.5627)
D*lnURB							-0.0132*** (-2.4561)
CONSTANT	-11.3960*** (-24.2600)	-11.4178*** (-24.8959)	-11.5963*** (-20.8767)	-10.8672*** (-40.0590)	-10.5917*** (-33.2039)	-10.9939*** (-30.7240)	-11.3935*** (-24.2933)
Adj R^2 DW-stat	0.98 2.36	0.99 2.37	0.99 2.37	0.99 2.32	0.98 2.24	0.99 2.21	0.98 2.36

***, ** and * denote 1%, 5% and 10% level of significance, respectively; t-statistics in parenthesis

5. Conclusion and policy implications

This study has analyzed two main issues: the contribution of urbanization, natural resource extraction and political regime to Tunisia's rising energy consumption but falling energy intensity; and the effect of structural change on the drivers of energy consumption and intensity. Inspired by the STIRPAT framework, Tunisia's energy consumption and intensity were modelled as a function of income, trade openness, urbanization, political regime, forest extraction, mining extraction and oil extraction. The study employed the fully modified ordinary least squares method which is able to eliminate the endogeniety and serial correction problems in the estimation process for an annual time series. Over the 1971-2013 period income, forest extraction, oil extraction and urbanization were found to increase total energy consumption while mining activities and political regime were found to exert negative effect on total energy consumption. However, income, political regime, urbanization and mining activities were found to reduce energy intensity. This shows clearly how some variables exert different effects of energy usage base on the measurement.

An asymmetric analysis of the drivers of energy consumption and intensity revealed that the factors of energy usage have been largely influenced by structural changes. That is the pre-1986 economic adjustment programme (EAP) effect tend to differ from the post-structural adjustment programme effect of the variables. For instance, while the income effect on total energy consumption is positive for the pre-EAP period, it becomes negative for the post EAP period. Also, the pre-EAP effect of trade openness is insignificant but positive. However, trade was found to exert significant negative effect on total energy consumption for the post-EAP period implying that trade openness has been energy reducing in the case of Tunisia after the EAP. Forest extraction though was found to have a positive but insignificant effect on total energy consumption for the pre-EAP period but it turned out to have direct significant effect post-EAP period. Thus, the forest extraction activities have not employed energy-efficient techniques over the period of study.

Further, while oil extraction has been reducing total energy consumption, mining activities have been increasing total energy consumption for post-EAP period in the country. In this regard, the EAP has made the oil sector more energy efficient than the mining sector. Political regime and urbanization were also found to exert significant opposite effects on total energy consumption for the pre- and post-EAP periods. That is, while political regime has increased energy consumption, urbanization has reduced energy consumption for the post-EAP period. The energy reduction effect of urbanization can be explained by the compact city theory while the increasing energy subsidy by the government can explain why political regime increases energy consumption.

With regards to energy intensity, the negative effects of income and urbanization were greater for the post-EAP than pre-EAP period. Also, urbanization has driven the economy towards lower energy intensity which is a confirmation of the city theory. Then again, trade openness reduces energy intensity post-EAP period while the opposite is the case for the pre-EAP period. Both political regime and forest extraction increase energy intensity post-EAP period while the opposite is the case for the pre EAP period.

In effect, one sees that the post-EAP effect of the variables, except for political regime, mining and forestry extraction activities on energy consumption and intensity, promote energy efficiency. The above findings have some policy and practical implications for the Tunisian economy. In all, the results imply that efforts directed towards reducing Tunisia's energy intensity would help improve the country's energy security. Specifically, since many poor Tunisians are into the forestry extractive activities it is necessary to subsidize energy efficient machines to enable them to acquire such equipment for usage in order to reduce energy intensity effect of the sector. Secondly, attention needs to be paid to Tunisia's mining sector to make the firms more efficient. Mining firms in the country that import or use inefficient technology can be taxed more than those with efficient technology. Thirdly, oil extraction has been reducing energy usage for the post-EAP period giving an indication that technically, there has been an improvement in the characteristics of the oil sub-sector as firms have moved towards more energy efficient methods of production. This could be as a result of the competition the sector has witnessed following the EAP. It is imperative for such healthy competition among firms in the sector to continue to promote efficiency in the usage of energy. Therefore, attempts to consciously or unconsciously create monopolist or oligopolists in the oil sector should not be entertained.

Regarding the effect of income on energy consumption and energy intensity over the years in Tunisia, the results imply that policies geared towards the attainment of higher per capita income will improve energy efficiency in the country. It is crucial for the policymakers to aggressively pursue the goal of the five-year development plan for 2016–2020 which is to achieve an annual growth rate of more than 4 percent by 2020 which will help promote further efficient use of energy as individuals' standard of living is likely to be improved hence their ability to afford environmentally friendly electrical gadgets. One of the pillars of the country's five-year development plan is the establishment of the green economy for sustainable development. Strategizing on the part of policymakers to ensure this pillar sees the day of light will be much helpful towards sustainable energy for the country.

The political regime has over the years reduced energy usage except for periods after the EAP. This suggests that the rising energy subsidy associated with the post EAP period in Tunisia may not have promoted energy conservation. If the government can gather the courage to reduce subsidies on energy it may lead to lower energy intensity. Further, intensive education to sensitize the populace on energy conservation issues can be helpful. The significant energy-reducing-effect of trade openness post-EAP as against the positive effect for the other period is an indication that by opening up to international trade Tunisia has witnessed the importation of high efficient equipment that consume less energy. However, it is important for the country to increase tariff and non-tariff barriers on products that do not promote energy efficiency and vice versa.

It is also necessary for the government of Tunisia to encourage investment activities on research and development to deepen the formulation of an improved energy savings technology to meet the rising demand for energy in the urban areas. More so, urban policies that might trigger further compaction and persuade behavioral changes among all actors in the system should be implemented.

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