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An Empirical Analysis of Energy Demand in Tunisia

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Abstract

This article assesses the impact of real energy prices on the consumption of different energy sources in Tunisia. We estimate the short-run and long-run energy demand elasticities over the period 1980-2004, where energy demand is specified by a simple partial adjustment model. Our results show that energy demand in Tunisia is generally sensitive to the income level and real prices of energy products. Moreover, the price elasticity and income elasticity differ across energy sources. These findings imply that energy price increases will not only affect energy demand, but also give rise to substitution effects between different forms of energy.

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1. Introduction

Analyzing energy demand is a crucial task for better understanding the energy system and for building appropriate energy planning. This task usually involves the investigation of energy demand sensitivity to price changes and other driving factors. Various approaches have been proposed to model the dynamics of energy demand in different countries or panels of countries (e.g., Amarawickrama and Hunt, 2008; Broadstock and Hunt, 2010; Agnolucci, 2009; Park and Zhao, 2010; Matsuo et al. 2013).

For instance, Amarawickrama and Hunt (2008) estimate electricity demand functions in Sri Lankan by using six different methods including the structural time series model (STSM) over the period 1970-2003 and show that the considered techniques perform as well as the cointegration approach. Note that only the STSM allows for an exogenous nonlinear trend to be identified. Broadstock and Hunt (2010) consider the UK transport oil demand function over the period 1960-2007, which incorporates a proxy for fuel efficiency, and attempt to find the relative importance of the economic drivers (price and income) and the non-economic drivers (fuel efficiency and the underlying energy demand trend - UEDT). Their results indicate that the UEDT plays a relatively more important role in determining the UK transport oil demand. Similarly, Agnolucci (2009) uses the STSM and Ordinary Least Squares with asymmetric price responses to estimate the domestic and industrial energy demand functions in the United Kingdom, and concludes on the suitability of the STSM approach over the period 1973-2005. Park and Zhao (2010) study the gasoline demand function in United States over the period 1976-2008 and their results suggest that the price elasticity increased from 1976 to 1980, decreased from 1980 to 1986, increased from 1986 to 1994, decreased from 1995 to 2005, and decreased from 2005 to 2008. The estimated time varying income elasticity of gasoline demand function followed a similar pattern, but the magnitude is smaller. More recently, Matsuo et al. (2013) project energy supply and demand outlook in Asia and other regions of the world through 2035, and focus particularly on the relationship between Asia and the Middle East. Using energy economics models (a macroeconomic model, an energy supply and demand model, and a technology assessment model), these authors show that the Middle East will be able to respond to an expected substantial increase in Asian fossil fuel demand. Therefore, continuing appropriate investment in resource development in the Middle East will be necessary to ensure stability in global energy supply and demand.

The energy sector in Tunisia has been a successful era during the 1970s. It indeed played a leading role in the country's economic and social development process. In particular, crude oil exports have been a significant source of national income and a key determinant of economic growth in Tunisia over that period. The new economic environment of Tunisia, which began with a higher economic integration into the global economy, as well as its new status of net oil-importing country since 2000 would be expected to promote greater transparency in energy price formation. In addition, the pricing system and tax policies will better reflect the policy and budget constraints arising from the international economic environment.

This present study is concerned by the dynamic of energy demand in Tunisia over the period from 1980 to 2004. The latter is particularly characterized by a structural change in the energy sector (i.e., from a net-energy exporting to a net-energy importing country) as well as by some specificity such as Tunisian government's practices of price-caps regulation on the retail local market, energy product subsidies, and various special tax rates. Empirical insights from this period are of particular interest to policymakers as they help them to make sound adjustments of their energy policies. To do so, we use a simple partial adjustment framework to investigate the responses of energy demand to, among others, real energy prices and income. While a structural model with individuals and firms that maximize expected utility and profits over energy-using capital investments and energy consumption with respect to all other goods and available budget is needed, we decided to employ the partial adjustment model to analyze the dynamics of energy demand behavior. As noted by Paul et al. (2009), this model allows the energy demand function to change with respect to each of its determinants which are expressed in both its short-run and long-run forms. It also permits to overcome the unavailability of the data regarding consumers' energy-related decisions at both firm and household levels (i.e., purchases, utilization, prices, and characteristics of energy-consuming equipment).

The remainder of this article is organized as follows. Section 2 presents a brief overview of energy sector in Tunisia. Section 3 introduces the empirical framework and data used. Section 4 reports and discusses the estimation results. The last section concludes the article.

2. Overview of Energy Sector in Tunisia

During the 1970s and 1980s, the energy sector played an important role in economic development of Tunisia. Since the early 1970s, revenues from hydrocarbons exports, including crude oil and related petroleum products, contributed a large part to income surpluses that helped strengthen public finances. This situation was very favorable until the early 1980s, but the energy sector's contribution in economic growth has steadily declined owing to lower revenues from hydrocarbon exports which were caused by falling prices of petroleum products following the oil counter-shock of 1986. This change has induced a structural change as Tunisia moved from an energy-based surplus country to a net importer of energy.

On the other hand, the energy intensity showed different trends. While an increasing trend was observed during the 1980s mainly due to the acceleration of economic growth, a downward trend characterizes the evolution of energy intensity since the 1990s. Indeed, energy intensity decreased from 0.416 toe/MDT in 1990 to 0.352 and 0.323 toe/MDT in 2005 and 2007, respectively. This evolution is explained by the energy control policy and a structural change in production. It is important to note that petroleum products account for 70% in the final energy demand as end of 2006. The remaining 30% is shared between electricity (17%) and natural gas (13%). The scarcity of energy sources in Tunisia as compared with neighboring countries (e.g., Algeria and Libya) makes the energy policy issue under scrutiny.

3. Empirical method and Data

3.1 Model specification

We hypothesize that there exists, for Tunisia, a simple equilibrium demand relationship between energy demand, economic activity and real energy prices, as follows

$$D_i = L\left(p_i, p_j, y\right) \tag{1}$$

where D_i represents the demand for a particular energy *i*, p_i the price of the energy under consideration, *y* the income and p_j the price of substitutable energy products.

The model in Eq. (1) can be empirically tested and estimated by using the following conventional log-linear specification:

$$Ln(D_t) = \beta_0 + \beta_1 Ln(Y_t) + \beta_2 Ln(P_i) + \beta_3 Ln(P_j) + \varepsilon_t \tag{2}$$

All the variables in Eq. (2) are expressed in logarithmic terms, meaning that the associated coefficients will represent the elasticity of the energy demand to different variables. ε_t is a random error term. Interestingly, a partial adjustment process can be introduced so that we can discern the short- and long-term behavior of the energy demand. Specifically, the desired level of energy demand at time *t* (D_t^d) depends on the price (P_t), income (Z_t) and a random variable (U_t) as in Eq. (3).

$$D_t^d = a + b^* P_t + c^* Z_t + U_t \tag{3}$$

The effective demand level is expected to vary from one period to another in proportion to the difference between the desired demand at time *t* and the actual demand at time *t*-1:

$$D_t - D_{t-1} = \gamma^* \left(D_t^d - D_{t-1} \right) \tag{4}$$

Combining Eq. (3) and Eq. (4) yields the following equation:

$$D_t = a\gamma + b\gamma^* P_t + \left(1-\gamma\right)^* D_{t-1} + c\gamma^* Z_t + \gamma U_t \tag{5}$$

The coefficient associated with P_t gives the short-term effect of energy prices. The long-term effect is obtained by dividing the coefficient of P_t by γ, where γ is a parameter that takes values between 0 and one. When $\gamma = 0$, no adjustment to the desired demand is possible and the demand remains at its initial level. When $\gamma = 1$, the adjustment to the desired demand is instantaneous and there is inertia (i.e., the model is static). In intermediate cases where $0 < \gamma < 1$, the convergence to equilibrium demand may occur asymptotically. Similarly, the short-term effect of the variable Z_t is given by its associated coefficient, while its long-term effect is obtained by dividing that coefficient by γ.

3.2 Data

Our data consist of annual data over the period 1980–2004. As stated earlier, the choice of this sample period is particularly justified by the availability of the data used and the structural change in the energy profile of Tunisia. Indeed, not only the dataset is inconsistent before 1980 but also the energy production by product is not available. Moreover, Tunisia has switched from a net-energy exporting to a net-energy importing country during this period. Coupled with the price-caps regulation policy on the retail local market, energy product subsidies, and various special tax rates, this structural change is likely to have significant effects on the energy demand sensitivity.

Table I. Summary statistics of variables

	PHYD	DPIB	VAI	Rmeg	PGN	PES	PPL	PGO	PFL	PFD	PGPL
Mean	116.51	2159.02	19428.29	13122.15	495.34	170.13	295.82	221.59	361.90	279.70	168.17
Max.	150.00	2858.80	161335.90	17568.40	588.27	220.00	370.00	250.00	478.00	350.00	194.00
Min.	66.40	1209.20	8527.90	8527.90	299.97	100.00	145.00	124.70	153.20	207.70	111.50
Std. Dev.	29.79	583.06	31813.24	2992.98	78.18	31.94	60.04	34.57	97.11	44.16	24.34
Skew.	-0.33	-0.19	4.31	-0.04	-0.93	-0.88	-1.15	-1.83	-0.56	-0.02	-0.69
Kurt.	1.60	1.53	19.75	1.57	3.25	3.00	3.76	5.18	2.53	1.75	2.59
JB	2.18	2.12	325.48$^+$	1.88	3.26	2.83	5.35	16.61$^+$	1.34	1.43	1.92
Obs.	22	22	22	22	22	22	22	22	22	22	22

Notes: this table reports the mean, maximum (max.), minimum (min.), standard deviation (Std. Dev.), skewness (skew.), kurtosis (kurt.), Jarque-Bera test for normality (JB), and number of observations (Obs.). + indicates the rejection of normality at the 5% level. PES, PFD, PFL, PGN, PGO, PGPL, PPL, PHYD, DPIB, VAI, and Rmeg stand for gasoline price, domestic fuel price, light fuel price, natural gas price, diesel oil price, liquefied petroleum gas price, lamp petroleum price, hydrocarbon price index, GDP deflator, industry value added, and household revenues, respectively.

The data on energy consumption (in ktoe) by product (electricity, petroleum products, and natural gas) and by sector data (industrial, transport, and residential sectors) for Tunisia are taken from the National Energy Management Agency (ANME) and Tunisian Company Electricity and Gas (STEG). We consider the total energy demand function, and energy demand functions for crude oil, petroleum products, electricity, and natural gas. The data on economic activity (GDP at constant prices) and energy price indices are obtained from the National

Institute of Statistics (INS). Note that we use an average price index for natural gas. Summary statistics of all variables used are presented in Table 1. We see that all of them are normally distributed, except the VAI and PGO variables.

4. Results and discussions

Total demand includes all consumption of all sectors. We examine the elasticity of total energy demand with respect to income represented by GDP at constant prices and a price variable represented by the oil price index divided by the implicit GDP deflator. The best specification of this function is obtained from the partial adjustment model.

4.1 Dynamic adjustment of total demand function

The income elasticity of total energy demand is about 0.9. This implies that total demand is growing at a rate slightly below the growth rate of GDP. The price elasticity is approximately -0.25 over the long run, indicating that energy demand is generally price inelastic. The reaction of economic agents to price changes is more important in the long run than in the short run.

Table II. Estimated elasticity for total energy demand

	Income elasticity	Price elasticity
Total demand	0.90[b]	-0.25[b]
Final residential demand	1.33[a]	0.00[a]
Final industrial demand	0.80[a]	-
Final demand for transport	0.57[a]	- 0.45[a]

Notes: (a) short- run; (b) long- run.

The income elasticity of the energy demand from the industry and transport sectors is lower than that related to residential demand. The price elasticity of these sectors is also relatively low. On the other hand, the energy demand from the residential sector is resilient relative to income as a 1% increase in the income leads to an increase of 1.33% in energy demand. This finding suggests that improving living standards is reflected by an increase in the share of households' energy demand in the total energy consumption.

4.2 Dynamic adjustment of electricity demand function

Electricity demand is elastic with respect to income (1.3), implying that electricity consumption of the overall economy is growing at a faster rate than GDP. This high sensitivity can be partly due to the increase of equipment televisions, refrigerators, washing machines, video equipment and air conditioners. Our results also indicate that electricity demand is sensitive to the movements of prices of substitutable petroleum products as the electricity demand elasticity to this factor is about 0.23.

A more detailed analysis of the behavior of electricity demand by use shows that the residential demand elasticity is elastic with respect to income (1.78), which can be again explained by the improvement of living standards. The price elasticity of electricity demand has expected sign as the demand is reduced when the price is high. It ranges from -0.59 (for industrial demand) to -0.30 (for residential demand). The high sensitivity of industrial demand to energy prices may arise from the fact that the lifetime of the equipment used in this sector is relatively long, which usually implies immediate reaction to energy price changes.[1] It is also worth noting that the substitutability between electricity and petroleum products is around 0.2.

[1] We use the industrial added value and the electricity price to estimate the industrial demand function for electricity.

Table III. Estimated elasticity for electricity demand

	Income elasticity	Price elasticity	Elasticity of substitution
Total demand	1.31[a]	-0.54[a]	0.27
Industrial demand	1.32[a]	-0.59[a]	0.20
Residential demand	1.78[a]	-0.30[a]	0.14

Notes: (a) short- run; (b) long- run

4.3 Dynamic adjustment of petroleum products demand function

Table IV shows that oil demand is elastic relative to national income, but at a lesser extent than economic growth rate. A 1% increase in income leads to 0.67% increase in the total energy demand. At the sectoral level, we find that the income elasticity is low, in particular for the transport sector. This result is explained by efforts to enhance the energy efficiency in the sector, owing to improved engine performance. Regarding the price elasticity, it is weak for both residential and transport sectors as energy is the vital source for their regular functioning.

Table IV. Estimated elasticity for petroleum products demand

	Income elasticity	Price elasticity
Total energy demand	0.67[b]	-0.09[b]
Residential energy demand	1.06[a]	-0.03[a]
Transport energy demand	0.56[a]	-0.44[a]

Notes: (a) short- run; (b) long- run

4.3 Dynamic adjustment of natural gas demand function

Table V indicates that the total demand for natural gas increases with national income. Over our study period, the natural gas consumption grew at an average annual rate of about 10%. The income elasticity is higher in the residential sector (2.32) than in the industrial sector (1.35). The price elasticities are also relatively high for both economic sectors. The favorable (decreasing) trend in the relative price of natural gas over the recent periods appears to be the main driving force of the increased share of this energy in the total energy consumption.

Table V. Estimated elasticity for natural gas demand

	Income elasticity	Price elasticity	Elasticity of substitution
Total demand	1.35[b]	-1.12[b]	-
Residential demand	2.32[b]	-0.98[b]	0.48
Industrial demand	1.35[b]	-0.90[b]	0.26

Notes: (a) short- run; (b) long- run

5. Conclusion

This article analyzed the dynamics of energy demand function in Tunisia by product and by sector. Our results show that energy demand in Tunisia is generally very sensitive not only to income but also to energy prices, whatever the type of energy used. These results suggest that economic agents have to make efforts to consume less energy as their demand depends upon the levels of energy prices and income. Since we find some evidence of energy demand elasticity to the substitutability between different types of energy, tax policy may significantly affect the total demand.

Tunisia is gradually moving towards replacing petroleum with natural gas. To the extent that this country also becomes a net importer of energy, an appropriate pricing policy which encourages all levels of competition and choice of fuels seems to be highly suitable.

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