Short and long run elasticities of Gasoline and Diesel demand in Algeria: an empirical analysis using fuzzy linear regression

تقدير مرونة الطلب على الوقود في المديين القصير والطويل في الجزائر: دراسة قياسية باستخدام الانحدار المبهم

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Abstract:

In oil dependent and fuel subsidized countries like Algeria, high consumption of fuel products poses real threats to macroeconomic stability and growth. Gasoline and diesel are by far the most important petroleum products. This paper estimates the long run and short run price and income elasticities for gasoline and diesel demand in Algeria for the period 1991-2016.The Tanaka fuzzy regression method has been applied. The empirical results reveal that both long run and short run income elasticities of gasoline and diesel demand in Algeria are more elastic than their counterparts price elasticities.

Keywords: Gasoline demand; Diesel demand; Elasticities; Fuzzy regression; Algeria;

Jel Classification Codes : Q41; H2;C13

الملخص :

في البلدان التي تعتمد بشكل كبير على النفط والوقود المدعوم مثل الجزائر، يشكل الاستهلاك المرتفع لمنتجات الوقود تهديدا حقيقيا لاستقرار الاقتصاد الكلي والنمو الاقتصادي. يعتبر البنزين والديزل من أهم المنتجات البترولية. تهدف هذه الورقة البحثية لتقدر مرونة السعر والدخل في المدى الطويل والقصير للطلب على البنزين والديزل في الجزائر خلال الفترة 1991-2016 باستخدام طريقة الانحدار الضبابي لتاناكا. بينت النتائج أن مرونة الدخل للطلب على البنزين والديزل في المدى الطويل والقصير أكثر مرونة من مرونة السعر.

الكلمات المفتاحية: الطلب على البنزين، الطلب على الديزل، المرونات ،الانحدار المبهم، الجزائر.

تصنيف JEL: **Q41; H2;C13**

1. Introduction:

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The energy consumption in Algeria has significantly increased over the last ten years by approximately 35 percent. In fact, from 2000 to 2016, consumption of gasoline has increased by about 58 percent, while consumption of diesel has increased by 26 percent. This increase in domestic fuel consumption is due in part to the local fuel prices, which have remained artificially very low thanks to generous government subsidies, leading to more fuel consumption. Additionally, two other factors have substantially contributed in increasing fuel consumption in Algeria. First, the rapid increase in Algeria's population growth. Second, the unprecedented increase of cars imports over the last five years, leading to a significant increase in the number of cars on the road in Algeria, from 3 211 052 car in 2005 to 5 986 181 cars in 2016, which means more fuel is needed.

However, the sharp decline in oil prices that started in mid-2014 created concern among Algerian policy makers, due to the fact that the Algerian economy is heavily dependent upon the country's oil and gas revenues. Consequently, Algerian government has become under pressure to reconsider the level of subsidies it provides for fuel products, and the prices of gasoline, diesel and electricity are expected to rise significantly. In December 2015, the Algerian government announced an increase in the prices of fuel and electricity as part of 2016 budget law corrective measures. According to Algeria 's finance minister Abdurrahman Raouia, the government plans to end subsidizing fuel prices starting from 2019. We think, therefore, that the estimation of fuel demand elasticities is necessary because it gives policy makers information about the development of fuel consumption in response to changes in income and prices.

The aim of this study is to estimate the short-run and long-run price and income

elasticities of gasoline and diesel demand in Algeria using the fuzzy regression analysis. However, as far as we know, no previous research has estimated fuel demand elasticity using fuzzy regression approach.

This paper is organized as follows: section 2 reviews very briefly some existing economic literature on gasoline and diesel demand elasticity estimates. Section 3 offers an overview of the pattern of gasoline and diesel consumption in Algeria. Section 4 presents the models, the data, and the methodology of estimation. Section 5 presents the results and discussions, while section 6 concludes.

2. Literature review:

There are a large number of studies that have examined the determinants of demand for gasoline in both developing and developed countries. These studies cover a wide range of quantitative methods and data periods. Primary studies on gasoline demand modeling and elasticity estimates have been carried out by Dahl and her associates (Dahl 1986; Dahl and Sterner 1991; Dahl 2012). Dahl (2012) summarized the elasticities for gasoline and diesel fuel consumption from the historical studies, and developed a database of prices and income elasticities for gasoline and diesel demand for 124 countries. Dahl (2012) found that the gasoline price elasticities developed from historical studies ranged between -0.11 for middle income economies with lower gasoline prices, and -0.33 for high income per capita economies with high gasoline prices, while price elasticities for diesel ranged between -0.13 and 0.38. The author also found the income elasticites for gasoline fall from lower to higher income per capita. The income elasticities developed by Dahl ranged between 1.26 and 0.66.

Espy (1998) used meta-analysis approach to investigate factors that systematically affect price and income elasticities estimates in diverse studies of gasoline demand made within 1966-1997. The author found that there is a variation in the elasticity of demand across countries, particularly in the short run. However, the author's results did not indicate any systematic pattern that explains these variations. According to Espy (1998)'s survey the average short and long run price elasticity estimates for gasoline demand were -0.26 and -0.58, respectively. While the short and long run gasoline income elasticities averaged 0.47 and 0.88 respectively.

In addition, Brons et al.(2008), Havranek et al. (2012) and Havranek and Kokes (2015) provided reviews based on hundreds of gasoline demand studies. The reviews of Brons et al.(2008) show the average price elasticities of gasoline demand to be -0.34 in the short run and -0.84 in the long run. Furthermore, the authors find that geographic area studied, type of data used, the time horizon and the functional specification of the demand equation have a significant impact on the estimated value of the price elasticity of gasoline demand.

Havranek et al. (2012) and Havranek and Kokes (2015) demonstrated that there is substantial publication bias in the previous studies on the price elasticity of gasoline demand. The authors reported that the estimated short and long run gasoline price elasticities were exaggerated twofold because of publication selection. Consequently, Havranek et al. (2012) found that the short and long run price elasticities averaged -0.09 and -0.31, respectively. Havranek and Kokes (2015)'s results suggest that income elasticity of gasoline demand is on average much smaller than reported in previous studies. The authors found that the short and long run gasoline income elasticities averaged 0.1 and 0.23 respectively. Based on the results of these

above studies, it can be concluded that demand for gasoline is price inelastic in the short and long term.
Because in this paper we are interested in estimating price and income elasticities of gasoline and diesel demand in Algeria, and given the fact that Algeria is an oil country, we focus particularly on previous studies that have econometrically estimated gasoline and diesel demand elasticities in oil exporting countries and in Algeria either specifically or within a group or panel. A brief summary of this literature is provided in Table 1and discussed in this section.
Eltony (1994) and Eltony and Al-Mutairi (1995) studied the gasoline demand in Kuwait. The author found that Kuwait gasoline demand is not responsive to price changes, but very responsive to changes in income, because gasoline prices in Kuwait are heavily subsidized.
Eltony and Elmahmeed (1993) studied gasoline demand in the Gulf Cooperation Council Countries (GCC) using pooled time series and cross section country data for the period from 1975 to 1989. Their results indicate that demand for gasoline is inelastic with respect to both price and income in the short or the long term, because in the GCC countries price of gasoline is highly subsidized.
Al-Sahlawi (1988, 1997), Al fares (1992, 1997), and Atalla, and al. (2018) concentrated on modeling gasoline demand in Saudi Arabia. The majority of these studies found that gasoline demand in Saudi Arabia is generally price and income inelastic in both the short and the long run.
Ahmadian, Chitnis and Hunt (2007) and Taghvaee and Hajiani (2014) estimated price and income elasticities of gasoline demand using different estimation methods Static, ECM, and Dynamic Models) in Iran. They argued that gasoline demand is price and income inelastic in both the short and long run.
In a recent paper, Arzaghi and Squalli (2015) estimated the price and income elasticity of demand for gasoline in 32 fuel subsidizing economies over 1998-2010 period. They found that gasoline demand is price inelastic for both the short and long run. The authors claimed that a progressive removal of fuel subsidies in these economies can free up considerable resources to invest in education, healthcare and infrastructure.
As far as we are aware, only a few studies have dealt with gasoline and diesel demand elasticities in Algeria. For instance, Dahl (2012) compiled gasoline and diesel demand elasticities for more than 124 countries including Algeria. The author's survey report gasoline and diesel price elasticities of -0.30 and -0.22 respectively, and income elasticities of 1.05 and 1.87 respectively, in Algeria.

Bhattacharyya and Blake (2009) estimated the elasticities for petroleum products in seven MENA countries namely: Algeria, Iran, Kuwait, Libya, Saudi Arabia, UAE and Qatar, during the period 1982-2005. Contrary to expectation, Bhattacharyya and Blake (2009) found that the price elasticities of demand for gasoline and diesel in Algeria were positive. While, income elasticities for both gasoline and diesel demand gave the expected positive signs. The authors offered two reasons to justify the unexpected signs of price elasticities in some MENA countries. First, MENA countries have a relatively low price for fuel products. Second, the prices of gasoline and diesel products were relatively stable, which does not allow the model to capture possible price elasticities.

Interesting thing about the literature on gasoline and diesel demand modeling in oil exporting countries, including Algeria, shows that consumption of fuel products is more responsive to changes in income than real prices, this therefore, because prices are highly subsidized in these countries.

Table 1. Previous oil exporting countries gasoline demand studies

Study	Country	Estimated period	Fuel Type	Price elasticity		Income elasticity	
				LR	SR	LR	SR
Eltony (1994)	Kuwait	1970-1989	Gasoline	-0.205	-0.043	1.617	0.32
Eltony and Al-Mutairi (1995)	Kuwait	1970-1989	Gasoline	−0.46	−0.37	0.92	0.47
Al-Sahlawi (1988)	Saudi Arabia	1970–1985	Gasoline	−0.67	−0.08	0.92	0.11
Al-Faris (1992)	Saudi Arabia	1970–1990	Gasoline	−0.30	−0.08	0.07	0.02
Atalla and al. (2018)	Saudi Arabia	1979-2016	Gasoline	−0.15 −0.09		0.15 0.61	
Taghvaee, and Hajiani, (2014)	Iran	1976-2010	Gasoline	−0.36	−0.15	0.72	0.22
Ahmadian et al. (2007)	Iran	1968-2002	Gasoline	−0.74	−0.19	1.25	0.32
Arzaghi and Squalli (2015)	32 fuel subsidized countries	1998–2010	Gasoline	−0.25	−0.05	0.81	0.16
Eltony (1994)	GCC countries	1975–1989	Gasoline	−0.11 to −0.13	−0.09 to −0.11	0.23 to 0.48	0.21 to 0.41
Eltony (1996)	GCC countries	1975–1993	Gasoline	−0.17	−0.11	0.48	0.31
Dahl (2012)	Algeria	Till 2010	Gasoline	-0.30		1.05	
			Diesel	-0.22		1.87	
Bhattacharyya and Blake (2009)	Algeria	1982-2005	Gasoline	--	0.082[a]	--	0.489
			Diesel	0.296[a]	0.046[a]	3.623	0.560
	Iran		Gasoline	-0.303	-0.124	0.577	0.652
			Diesel	-0.129	-0.055	0.853	0.365
	Kuwait		Gasoline	-0.303	-0.143	0.577	0.272
			Diesel	-2.694	-0.404	-0.185[a]	-0.028[a]

	Libya		Gasoline	- 0.548	- 0.081	0.373[a]	- 0.055[a]
			Diesel	1.585[a]	0.370[a]	-0.863[a]	- 0.202[a]
	Qatar		Gasoline	- 0.133	- 0.098	0.286	0.210
			Diesel	--	- 0.149	--	- 0.119[a]
	Saudi Arabia		Gasoline	0.002[a]	0.008[a]	0.732	0.136
			Diesel	- 0.033	- 0.013	0.455	0.174
	UAE		Gasoline	- 1.064	- 0.188	0.950	0.168
			Diesel	0.163[a]	0.020[a]	1.557	0.195
a: unexpected signs							

3. Methodology:

3.1. Model specification and data:

According to the earlier studies, fuel products (especially gasoline and diesel) are a function of the price of fuels and income. Therefore, following Eltony (1994) and Bhattacharyya and Blake (2009) among others, the present study specifies the following models:

$$G_d = F(P_g, Y, G_{d(t-1)}) \text{ ....(1)}$$

$$D_d = F(P_d, Y, D_{d(t-1)}) \text{ ....(2)}$$

Where: $G_d, P_g, and\, G_{d(t-1)}$ are per capita demand for gasoline, the real gasoline price and lagged consumption of gasoline, respectively. $D_d, P_d, and\, D_{d(t-1)}$ are per capita demand for diesel, the real diesel price and the lagged consumption of diesel, respectively.

The log linear relationship for equations 1 and 2 can be presented as:

$$Ln\,G_{dit} = a_0 + a_1\, LnP_{git} + a_2\, LnY_{it} + a_3\, LnG_{d(it-1)} + e_t \text{ ....(3)}$$

$$Ln\,D_{dit} = b_0 + b_1\, LnP_{dit} + b_2\, LnY_{it} + b_3\, LnD_{d(it-1)} + u_t \text{ ....(4)}$$

Where: $e_t\ and\ u_t$ are the error term in the equation 3 and 4 respectively. $a_1\,(b_1)\ and\ a_2\,(a_2)$ represent the short run price and income elasticities for gasoline demand (Diesel demand), respectively, and $a_1/(1-a_3)\, and\, b_1/(1-b_3)$ represents the long run price and income elasticities.

After the dynamic model estimation, we estimate a static model. According to Dahl (2012) elasticity estimates based on a static model are typically between the short run and long run estimates on dynamic models. The static model is as follows:

$$LnG_{dit} = a_0 + a_1\, LnP_{git} + a_2\, LnY_{it} + e_t \text{ ....(5)}$$

$$Ln\,D_{dit} = b_0 + b_1\, LnP_{dit} + b_2\, LnY_{it} + u_t \text{ ....(6)}$$

where parameters $a_1\,(b_1)$ *and* $a_2\,(a_2)$ are labeled intermediate run elasticities (Dahl ,2012).

The data used in this study include gasoline and diesel consumption, gasoline and diesel prices, and income in Algeria, covering the 1991-2016 period. Gasoline and diesel consumption data are from the International Energy Agency (IEA) databases. Data on prices of gasoline and diesel are obtained from the Ministry of Energy of Algeria in local currency. Real prices are calculated using CPI from the World Bank (2017). The Real GDP per capita is calculated by dividing nominal GDP by the CPI and total population. The nominal GDP in local currency come from the World Bank (2017).

3.2. Estimation method

The previous literature on fuel demand showed a wide difference in estimated elasticities in different parts of the world. According to Dahl (1986) the differences in results of various studies can be explained by the differences in functional forms, data characteristics, and econometric techniques used by researchers. As we have seen, a number of previous studies have applied statistical regression to estimate the elasticities of fuel demand (for example Eltony, 1994; Bhattacharyya and Blake,2009). In the traditional statistical regression, the estimated coefficients are considered as crisp or exact number, the fact which is less realistic, particularly when we deal with fuel elasticities, and this what has repeatedly been proven in past studies. An alternative approach is the fuzzy regression, where the coefficients of the models are considered as a fuzzy number consisting of a spread and a center.

The fuzzy linear regression model was first introduced by Tanaka and al.(1982), and it is regarded as an extension of classical regression analysis in which some elements of the models (in most fuzzy regression models, dependent variable and coefficients are fuzzy) are considered fuzzy.

Many researchers have argued that fuzzy linear regression has several advantages than statistical linear regression. In fact, fuzzy regression may perform better than statistical regression in the following cases (Kim et al., 1996; He et al.,2005 ;Tseng and Lin, 2005):

- When the size of the data set is too small.
- When the available data are imprecise.
- When the aptness of the regression model is poor.
- When the regression model is poorly specified in its functional form.

The main objective of the fuzzy linear regression is to minimize the fuzziness of the model by minimizing the total spreads of fuzzy coefficients (Tahmasebi and Rocca,2015).

The general form of the fuzzy linear regression model proposed by Tanaka and al.(1982) is given as:

$$\tilde{Y} = \tilde{A}_0 x_0 + \tilde{A}_1 x_1 + \tilde{A}_2 x_2 + \ldots\ldots\ldots\ldots + \tilde{A}_N x_N \ldots\ldots(7)$$

Where:

$\tilde{Y}$ indicates the estimated dependent variable, which is assumed to be a symmetric triangular fuzzy number. N: the number of observations.

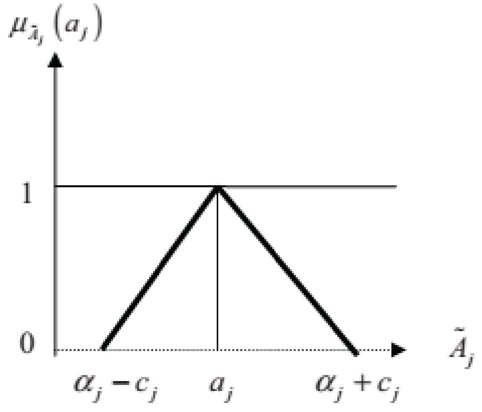
$x = [\ x_0, x_1, x_2, \ldots\ldots\ldots\ldots, x_N\ ]$ represents the value of the independent variables, which are no fuzzy number.

$\tilde{A} = [\ \tilde{A}_0, \tilde{A}_1, \tilde{A}_2, \ldots\ldots\ldots\ldots, \tilde{A}_N\ ]$ represents the fuzzy coefficients of the regression, demonstrated in the form symmetric triangular fuzzy numbers with centre α_j and spread c_j ,and $c_j \geq 0$,as $\tilde{A}_j = (\alpha_j, c_j)$, with the following membership function:

$$\mu_{\tilde{A}_j}(a_j) = \begin{cases} 1 - \dfrac{|\alpha_j - a_j|}{c_j} & \alpha_j - c_j \leq a_j \leq \alpha_j + c_j \quad \forall_j = 1,2,3,\ldots,N \ldots\ldots(8) \\ O,\ otherwise \end{cases}$$

The triangular membership function $\mu_{\tilde{A}_j}(a_j)$ of fuzzy regression is given in figure 01.

Figure 01. Triangular fuzzy regression coefficient



Therefore, the fuzzy linear regression model with the above membership function can be reformulated as:

$$\tilde{Y}_i = (a_0, c_0)x_0 + (a_1, c_1)x_1 + (a_2, c_2)x_2 + \ldots\ldots\ldots\ldots + (a_N, c_N)x_N \ldots\ldots(9)$$

To determine the optimal fuzzy coefficients $\tilde{A}_j = (\alpha_j, c_j)$ of the fuzzy regression model, while minimizing the total spread of the fuzzy number $\widetilde{Y}_i$,Tanaka et al. (1989) formulated a linear programming problem, as follows:

$$\begin{aligned}
&Minimize S = \sum_{j=0}^{m} c_j \sum_{i=1}^{n} |x_{ij}| \\
&subject\ to: \\
&\sum_{j=0}^{m} \alpha_j x_{ij} + (1-h)\sum_{j=0}^{m} c_j |x_{ij}| \geq Y_i \\
&\sum_{j=0}^{m} \alpha_{ij} c_{ij} - (1-h)\sum_{j=0}^{m} c_{ij} |x_{ij}| \leq Y_i \\
&c_j \geq 0, \quad j = 0,1,2,....m \\
&x_{i0} = 1,\ i = 1,2,3,....N \\
&0 \leq h \leq 1
\end{aligned}$$

Where:

S : denotes the total fuzziness of the fuzzy regression model.

m : the number of independent variables.

N : the number of observations.

h : refers to the membership function of fuzzy variables, its value range between 0 and 1.

The number of constraints in the fuzzy linear regression linear programming problems equals the number of regression coefficients plus the number of observations multiplied by two $(2 \times N)$.

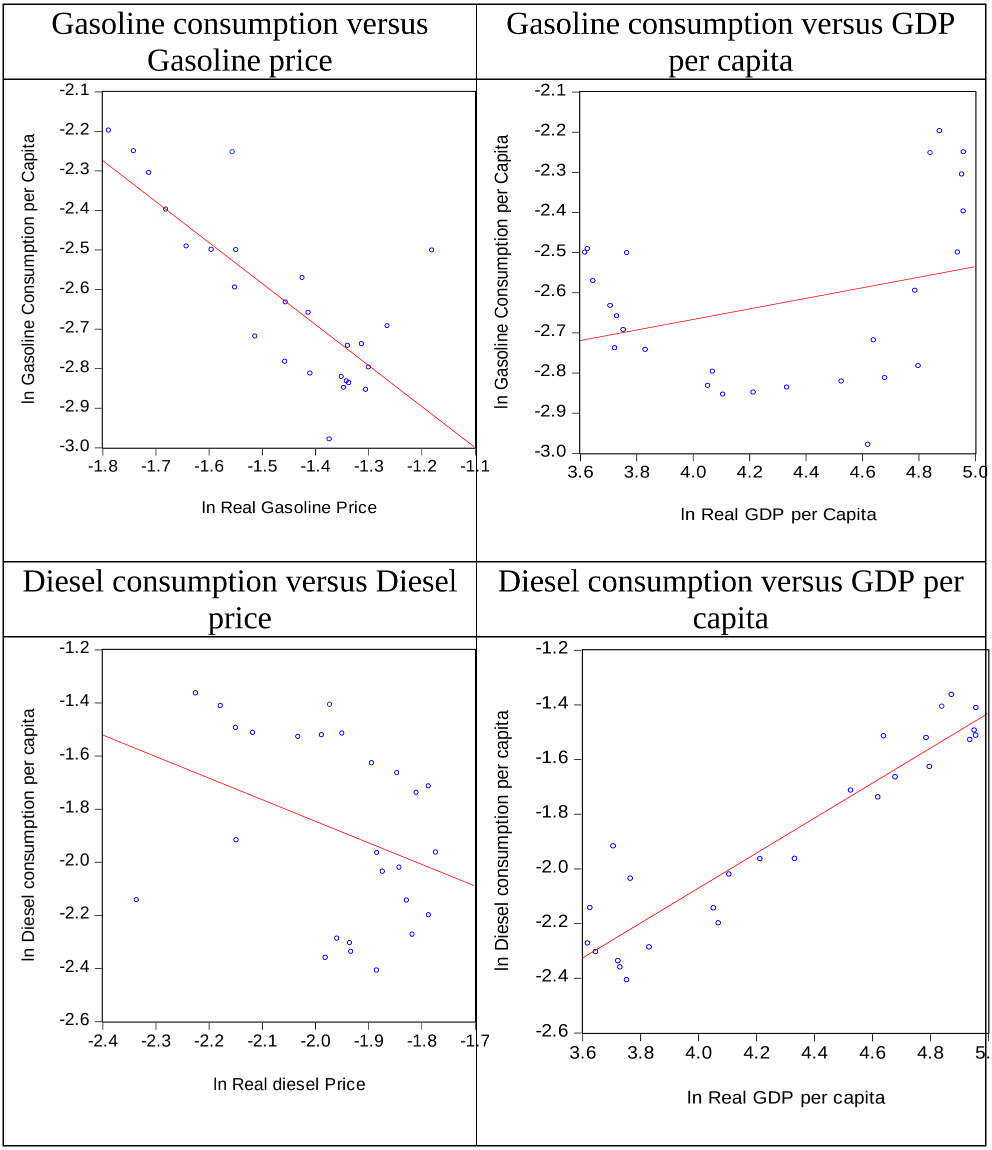
4. Results and discussion:

In order to explore short and long run price and income elasticities for gasoline and diesel demand, in the first step we start by checking the nature of the relationship between the independent and dependent variables via scatter plots, in the second step we perform the fuzzy linear regression analysis, and in the third step we evaluate the estimated results based on fuzzy regression models using goodness of fit measurement criteria which have been introduced and used by other researchers (Wang and Tsaur ,1997; D’Urso and Santoro ,2006).

4.1. Scatter plots for independent and dependent variables:

Before delving into the analysis of estimation results, we analyse the partial correlation between the dependent and independent variables of our two models. Partial correlation measures the degree of association between the two variables, with the exclusion of the effect of other controlling variables. The figure 2 below displays the simple correlations in the scatter plot.

Figure 2. Scatter plot of gasoline and diesel consumption versus their price and income



A careful look at the scatter plots show that gasoline consumption and diesel consumption are associated negatively with their prices. However, they are positively correlated with income per capita.

4.2. Empirical Results using Fuzzy linear regression method:

In this study, the fuzzy regression applied follows the Tanaka (1989) fuzzy regression method where the independent and dependent variables are crisp data, whilst the regression coefficients are given as a fuzzy numbers.

The following linear programming (LP) formulation was employed to estimate the fuzzy coefficients $\tilde{A}_j = (\alpha_j, c_j)$:

$$Minimize S = \sum_{i=1}^{26} (c_0 + c_1|x_{i1}| + c_2|x_{i2}| + c_3|x_{i3}|$$

$$subject\ to:$$

$$(\alpha_0 + \alpha_1 x_{i1} + \alpha_2 x_{i2} + \alpha_3 x_{i3}) + (1-h)(c_0 + c_1|x_{i1}| + c_2|x_{i2}| + c_3|x_{i3}|) \geq Y_i$$

$$(\alpha_0 + \alpha_1 x_{i1} + \alpha_2 x_{i2} + \alpha_3 x_{i3}) - (1-h)(c_0 + c_1|x_{i1}| + c_2|x_{i2}| + c_3|x_{i3}|) \leq y_i$$

$$c_j \geq 0,\ \ j = 0,1,2,3$$

$$x_{i0} = 1,\ i = 1,2,3,.....,26$$

$$0 \leq h \leq 1$$

In this study the above linear programming problem is solved using the LINGO 17.0 software program.

Therefore, the fuzzy regression models with the centre value α_j together with the corresponding spread c_j for the independent variables of both dynamic models and static models are obtained as follows:

Dynamic models:

$$\tilde{G}_{dit} = (-2.711,0) + (-0.0485,0)P_{git} + (0.1067,0.132)Y_{it} + (0.185,0)G_{d(it-1)} \ldots\ldots (10)$$

$$\tilde{D}_{dit} = (-4.461,0) + (-0.0308,0)P_{Dit} + (0.628,0)Y_{it} + (0.0408,0.226)D_{d(it-1)} \ldots\ldots (11)$$

Static models:

$$\tilde{G}_{dit} = (-3.42,0) + (-0.063,0)P_{git} + (0.152,0.15)Y_{it} \ldots\ldots (12)$$

$$\tilde{D}_{dit} = (-4.62,0) + (-0.044,0.25)P_{Dit} + (0.63,0)Y_{it} \ldots\ldots\ldots (13)$$

Table 2 presents the estimated short and long run price and income elasticities for gasoline demand and diagnostics tests. While table 3 report the results of the static models.

On the basis of the results reported in the table 2, the estimated price elasticities of gasoline demand are very low and have the expected negative signs. The short run price elasticity of gasoline demand is -0.048 and the long run corresponding elasticity is -0.058. These results imply that any one percent increase in price leads to a 0.06 percent reduction in gasoline demand in the long run. The short run gasoline price elasticity for Algeria is in line with that of Arzaghi and Squalli (2015) who report a -0.05 estimated price elasticity for 32 fuel subsidized countries. However, the estimated long run gasoline price elasticity for Algeria is much lower than the ones for those countries. Table 3 shows that short and long run income elasticities of gasoline demand are 0.106 and 0.13 respectively. Income elasticities signs are also in line with the economic theory. This means that a higher income increases the demand for gasoline in the long term, a result that confirms the dominant role played by income in the demand for gasoline in Algeria.

The results of the static model in table 3 give price and income elasticities of -0.063 and 0.15 respectively. When comparing the main model results in table 2 with the results of the static model in table 3, we still find that estimated gasoline income and price elasticities are generally small and inelastic (although larger than the elasticities produced in the main model).

The results for Diesel price and income elasticities are presented in table 2. The estimated short run and long run price elasticities for diesel demand are -0.0308 and -0.032 respectively, and the estimated short run and long run income elasticities are 0.63 and 0.65 respectively. For the static model in table 3, the estimated price and income elasticities for diesel demand are -0.044 and 0.63 respectively, suggesting that diesel demand is price and income inelastic.

The estimated results show that the average short-run and long-run income elasticities of diesel demand are higher than the average short-run and long-run income elasticities for gasoline demand in Algeria. Thus, diesel demand is more income elastic than gasoline demand. However, with respect to the price, the estimated short run and long run price elasticities for gasoline and diesel demand in Algeria are very close and extremely low.

In summary, as most oil exporting countries in the MENA region, gasoline and diesel price elasticities for Algeria are significantly smaller compared to other countries. This due in part to the local fuel prices, which have remained artificially very low thanks to generous government subsidies. Therefore, the demand for gasoline and diesel in Algeria are generally very inelastic with respect to price in both the short and long run, and they are more elastic but still less than one with respect to income. These elasticities are in line with the findings of previous fuel subsidized countries estimate discussed in section two, despite the different estimation method.

To evaluate our two fuzzy regression models, in this study we have used two goodness of fit measurement indices, including: ***i)*** Index of confidence (IC) which is similar to the coefficient of determination R^2 in statistics, according to Wang and Tsaur (1997) the higher the IC, the better is the y_i^c used to represent y_i ;***ii)*** The Average Absolute Error Percentage (AAEP) is also applied. The smaller AAEP, the better is the fitting quality of fuzzy regression models.

As shown in Tables 2 and 3, our two main models exhibit higher fitting power compared with the static models, since they have a large index of confidence (IC=0.92 for gasoline model, and 0.76 for diesel model). At the same time the gasoline main model has a small average absolute error percentage than its counterpart static model (AAEP= 0.0566 for gasoline dynamic model, and 0.0683 for the static model). However, a comparison of the two errors (AAEP) reveals that the diesel static model has smaller error than the dynamic model. The AAEP for the diesel static model was 0.0579 while the same error measurement for the dynamic model was 0.0684.

Table 02**. Estimated Gasoline and Diesel demand function for Algeria (main model results)**

Variables	**Obtained fuzzy regression Coefficients with center α_j and spread c_j**	
	Model 01: Dependent variable Gasoline consumption per capita (in logs) G_d	**Model 02 : Dependent variable Diesel consumption per capita (in logs) D_d**
Short run coefficients		
Price elasticity	**-0.048 ; 0**	**-0.0308 ; 0**
Income elasticity	**0.106 ; 0.132**	**0.628 ; 0**
lagged consumption coefficient	**0.185 ; 0**	**0.0408 ; 0.226**
Constant	**-2.711 ; 0**	**-4.461 ; 0**
Long run coefficients		
Price elasticity: $\hat{a}_1/(1-\hat{a}_3)$; $\hat{b}_1/(1-\hat{b}_3)$	**-0.058**	**-0.032**
Income elasticity: $\hat{a}_2/(1-\hat{a}_3)$; $\hat{b}_2/(1-\hat{b}_3)$	**0.13**	**0.65**
Diagnostics		
SSE/SST	**0.08**	**0.24**

Index of confidence: $IC = 1 - \frac{SSE}{SST}$	**0.92**	**0.76**
$AAEP = \frac{1}{n}\sum_{t=1}^{n}\left\|\frac{y_t - \hat{y}_c}{y_t}\right\|$	**0.0566**	**0.0684**
S: Total fuzziness of the fuzzy regression model	**14.78**	**10.745**
h	**0.5**	**0.5**
$SSE = 2\sum_{i=1}^{n}(y_i - \hat{y}_i^c)^2$ $SST = \sum_{i=1}^{n}(y_i - \hat{y}_i^L)^2 - \sum_{i=1}^{n}(y_i - \hat{y}_i^u)^2$		

Table 03**. Estimated Gasoline and Diesel demand function for Algeria (static model results)**

Variables	**Obtained fuzzy regression Coefficients with center α_j and spread c_j**	
	Model 01: Dependent variable Gasoline consumption per capita (in logs) G_d	**Model 02: Dependent variable Diesel consumption per capita (in logs) D_d**
Coefficients		
Price elasticity	**-0.063 ; 0**	**-0.044 ; 0.25**
Income elasticity	**0.152 ; 0.15**	**0.63 ; 0**
Constant	**-3.42 ; 0**	**-4.62 ; 0**
Diagnostics		
SSE/SST	**0.69**	**0.35**
Index of confidence: $IC = 1 - \frac{SSE}{SST}$	**0.31**	**0.65**
$AAEP = \frac{1}{n}\sum_{t=1}^{n}\left\|\frac{y_t - \hat{y}_c}{y_t}\right\|$	**0.0683**	**0.0579**
S: Total fuzziness of the fuzzy regression model	**16.85**	**12.81**
h	**0.5**	**0.5**

5. Conclusion and policy implications:

In this study an attempt has been made to estimate the long run and short run price and income elasticities for gasoline and diesel demand in Algeria for the period 1991-2016.The Tanaka fuzzy regression method has been applied due to its ability in handling imprecise and small dataset, inappropriate linearity assumption, and poor aptness of the regression model.

The results have shown that the long run and short run price elasticities of gasoline (-0.058; -0,048) and diesel (-0.032; -0.0308) in Algeria were found to be inelastic. The income elasticities of demand for gasoline and diesel are 0.106 and 0.63 in the short run, and 0.13 and 0.65 in the long run, respectively. Both long run and short run income elasticities of gasoline and diesel demand in Algeria are more elastic than their counterparts price elasticities.

These results reveal that gasoline and diesel demand in Algeria are very sensitive to change in income than price. These results are not surprising, due to the fact that domestic prices for fuels in Algeria are lower than the international market prices. Fuel prices are below the prices in the European Union and America, and lower than the prices in the Middle East. However, the higher sensitivity of gasoline and diesel demand to income changes may be explained by the simple fact that higher income in Algeria results in more cars import, and more fuel demanded.

In summary, the estimated price elasticities imply that a price increase would relatively reduce consumption of gasoline and diesel in Algeria. Hence, a gradual increase in fuel prices should be implemented to reduce fuel consumption, and the fiscal burden of government resulting from fuels subsidies.

References:

- Ahmadian, M., Chitnis, M., Hunt, L. C., 2007. Gasoline demand, pricing policy and social welfare in the Islamic Republic of Iran. OPEC Review, 31, 105-124.
- Arzaghi and Squalli (2015), How price inelastic is demand for gasoline in fuel-subsidizing economies?, Energy Economics 50 (117–124).
- Bhattacharyya, S.C., Blake, A., 2009. Domestic demand for petroleum products in MENA countries. Energy Policy 37, 1552–1560.
- Brons, M., Nijkamp, P., Pels, E., Rietveld, P., 2008. A meta-analysis of the price elasticity of gasoline demand. A SUR approach. Energy Economics. 30 (5), 2105–2122.
- Dahl, C.A., 1986. Gasoline demand survey. Energy J. 7 (1), 67–82.
- Dahl, C.A., Sterner, T., 1991. Analysing gasoline demand elasticities: a survey. Energy Economics. 13 (3), 203–210.
- Dahl, C.A., 2012. Measuring global gasoline and diesel price and income elasticities. Energy Policy 41, 2–13.

- D'Urso and Santoro (2006), Goodness of fit and variable selection in the fuzzy multiple linear regression, Fuzzy Sets and Systems 157 (2006) 2627–2647
- Eltony and Elmahmeed (1993), An Econometric study of the demand for gasoline in the Gulf Cooperation Council Countries, Surrey Energy Economics, discussion paper series, October 1993.
- Eltony, (1994), The demand for gasoline in Kuwait, OPEC Review, Autumn 1994.
- Eltony, M.N. and Al-Mtairi, N.H. (1995) Demand for Gasoline in Kuwait: An Empirical Analysis Using Cointegration Techniques. Energy Economics, 17, 249-253.
- Espey, M., 1998. Gasoline demand revisited: an international meta-analysis of elasticities. Energy Economics 20 (3), 273–295.
- Havranek, T., Irsova, Z., Janda, K., 2012. Demand for gasoline is more price-inelastic than commonly thought. Energy Economics . 34 (1), 201–207.
- Havranek, T., Kokes, O., 2015. Income elasticity of gasoline demand: a meta-analysis. Energy Economy. 47, 77–86.
- HE, Y.Q., Chan, L.K. & Wu, M.L. (2005) Balancing productivity and consumer satisfaction for profitability: Statistical and fuzzy regression analysis European Journal of Operational Research, 176, 252-263.
- Kim et al., 1996; Fuzzy versus statistical linear regression, European journal of operational research, Vol.92, N0.2,PP.417-434.
- Mohammed A. Al-Sahlawi,(1988), Gasoline demand The case of Saudi Arabia, Energy Economics, October 1988.
- Tanaka, H., S. Uejima, and K. Asai (1982). Linear regression model with fuzzy model. IEEE Transactions on Systems, Man and Cybernet 12: 903-907.
- Tarek N. Atalla, Anwar A. Gasim, Lester C. Hunt, (2018), Gasoline demand, pricing policy, and social welfare in Saudi Arabia: A quantitative analysis, energy policy, 114 (123-133)
- Taghvaee, V.M. and Hajiani, P. (2014) Price and Income Elasticities of Gasoline Demand in Iran: Using Static, ECM, and Dynamic Models in Short, Intermediate, and Long Run. Modern Economy, 5, 939-950.
- Tahmasebi and Rocca (2015), a fuzzy model to estimate the size of the underground economy applying structural equation modeling , Journal of Applied Economics. Vol. XVIII, No. 2 (November 2015), 347-368.
- Tseng, F.M. and LIN, L. (2005) A quadratic interval logit model for forecasting bankruptcy. Omega, 33, 85-91.
- Wang and Tsaur (1997), Insight of a fuzzy regression model, Fuzzy Sets and Systems 112 (2000) 355–369.