

## THE ESTIMATION OF THE AUTOMOTIVE FUEL DEMAND IN IRAN: ALMOST IDEAL DEMAND SYSTEM APPROACH

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### ABSTRACT

*This paper analyzes the demand for fuels in Iran automotive sector, using the Almost Ideal Demand System to estimate price and income elasticities for all the available fuels in the automotive sector: gasoline, automotive gas oil and Liquefied Petroleum Gas (LPG). These estimates can be very useful in predicting the overall impacts of price policies designed to reduce fuel consumption and to address concerns of carbon emissions or energy security. Empirical results indicate all own-price elasticities are negative and significant at 5% level. The own-price elasticity for gas oil, gasoline and LPG were estimated by about -0.22, -1.01 and -3.58, respectively. The findings also show that gasoline and gas oil are normal goods and LPG being an inferior good.*

**Keywords:** *Automotive fuel, Almost Ideal Demand System, Elasticity*

**JEL Classification:** *D11, C01*

### 1. INTRODUCTION

The demand of automotive fuel in the transport sector has always been a challenge to energy analysts, especially for long term energy policy. With growing energy and fuel consumption, the dependency on these scarce resources has become striking, as oil crises in the past and recent oil price developments indicate. In addition, environmental externalities caused by rising fuel consumption, such as emissions of carbon dioxide, nitric oxides, and carcinogenic airborne fine particulates from engines are becoming a major concern. Understanding the sensitivity of fuel demand to changes in prices and income has important implications for policies related to climate change, optimal taxation and national security, hence, policy-makers have an interest in how expected increases in income and fuel prices would affect fuel consumption and automobile use over time (Pock, 2009). In fact combustion of fuels in automobiles especially gasoline and volume of emissions generated by motor vehicles are amongst the most controversial issues faced by most governments and poses some of the most pressing policy concerns of the early twenty-first century.

For evaluation of price policies to control fuel consumption, one of the most critical considerations is the responsiveness of total fuel consumption to changes in fuel price. These are characterized by the price elasticity of demand for fuel and the income elasticity of fuel.

There is a vast literature on estimating price and income elasticities of automotive fuels demand (especially gasoline) at around the world; for instance, Samimi (1995) has identified cointegrating relationship between road transport energy demand and other macro-economic variables in Australia, he found that the output and price elasticities of energy demand in long-run are respectively (0.52) and (-0.12). Ramanathan (1999) uses the ECM to estimate elasticities in India and concludes relatively high long and short run elasticities of income (1.12 and 2.68 respectively) while price elasticities are estimated at -0.32 in the long-run and -0.21 in the short-run. Graham and Glaister (2002) argue that, in general, short run price elasticities lie between -0.2 and -0.3, whilst long run price elasticities tend to be between -0.6 and -0.8. Income elasticities in the short run are in the range 0.35–0.55, whilst long run income elasticities are typically greater than one, between 1.1 and 1.3. Nicol (2003) gasoline demand for the two countries: Canada and America. Cheung and Thomson (2004), gasoline demand For china, Akinboade and Kumo (2008) applied the Autoregressive Distributed Lag (ARDL) bounds testing approach to cointegration to analyze the gasoline demand for South Africa. They analyzed the long run relationship between the variables in the gasoline demand function over the period 1978-2005. Their study

confirms the existence of a cointegrating relationship and the estimated long run price and income elasticities were, respectively, -0.47 and 0.36, implying that the gasoline demand in South Africa is price and income inelastic. Rao and Rao (2008) gasoline demand for Fiji, Iooty and others (2009) demand for gasoline, ethanol, CNG and diesel for the country, Brazil. Most studies show that elasticity of gasoline demand suggests that it is necessary goods and also has low price and income elasticity and price elasticity is not significant.

However, there are considerable studies about the estimation of demand elasticities of gasoline for the Iran. For instance, Khataie and Eghdami (2005) estimated of gasoline demand during 1980-2002 periods, they show that there is a weak relationship between price and demand for gasoline in Iran. Ismaeilniya (2000) and Chit Nice (2005) concluded the gasoline demand function is inelastic in both in the short term and long term. Another study by Khaksari and Bazdar Ardebili (2006) estimated demand for gasoline and diesel in the land transportation sector (roads and railways); they show that gasoline and diesel demand in the land transportation sector with regard to the fuel price variation has a low elasticity. This indicates that fuel demand decreases less than one percent when the fuel price increases one percent. Also fuel income elasticity in the land transportation sector is less than one unit that shows when added value increases one percent, fuel demand increases less than one percent in the country. Sobhani and Zarezade Mehrizi (2005) estimates of gasoline demand during 1979-2003 period, they concludes that gasoline demand function is inelastic to price, and the gasoline consumption has a direct relationship with gross domestic product without oil, that the number the vehicles produced per year, that the urban population is an effective factor in demand for gasoline. Also Akhane (1999) estimated demand for transportation fuels in the transportation sector (roads and railways, air ways) using a simple OLS method ,during 1974-1995 , results indicate very low income and price elasticity for gasoline, but diesel income elasticity is relatively higher. Generally the cited studies suggest that Iranian Gasoline demand is inelastic with respect to price in the short and long run but larger in the long run.

In this paper, we estimate the price and income elasticity of demand for automotive fuel in Iran. No previous studies, as far as is known, have attempted to estimates the price and income elasticities for all the available fuels in the automotive sector in the Iran. Therefore, we adopted a system of demand approach and included all the fuel.

The paper is organized as follows. Section two describes the linear approximation of the AIDS model. Section three presents the data used. Then, in Section 4, main results are presented. The fifth, and last section, presents in a nutshell the main conclusions.

## 2. METHODOLOGICAL FRAMEWORK

The elasticities of energy consumption in the Iranian automotive segment, in the 1997-2008 period, are estimated through a linear approximation of the Almost Ideal Demand System (here by called LA-AIDS) estimated through a linear approximation of the Almost Ideal.

The Almost Ideal Demand System was developed by Deaton and Muellbauer (1980a, b). The AIDS model is indirectly non-additive and consistent with the requirements of demand theory, and therefore is an appropriate choice for estimating demand for gasoline, gasoil, and LPG. The AIDS model has many desirable attributes: (a) it is an arbitrary first order approximation to any demand system, (b) it satisfies the axioms of choice, (c) it aggregates over consumers, (d) it has a functional form consistent with previous household budget data, and (e) it is easy to estimate. The estimated coefficients in a linear approximate almost ideal demand system (LA/AIDS) model are easy to interpret (Fulponi, 1989). Also, the AIDS model allows testing for homogeneity and symmetry. The AIDS model has been extensively used in empirical work (Eales and Unnevehr, 1988; Hayes et al., 1990; Green and Alston, 1988; Foster et al., 1990; Chalfant, 1987; Fulponi, 1989; Ray, 1984).<sup>1</sup>

The AIDS model is:

$$W_i = \alpha_i + \sum_j \gamma_{ij} \ln P_j + \beta_i \ln \left( \frac{X}{P} \right) \quad (1)$$

where  $W_i$  is the budget-share associated with the  $i$ th good,  $\alpha_i$  the constant coefficient in the  $i$ th share equation,  $\gamma_{ij}$  is the slope coefficient associated with the  $j$ th good in the  $i$ th share equation, total expenditure  $X$  is given by  $X = \sum_{i=1}^n p_i q_i$  in which  $q_i$  is the quantity demanded for the  $i$ th good,  $P_j$  is the price on the  $j$ th good and  $P$  is a linear price index defined as  $\sum_{i=1}^n w_i \ln P_i$

The conditions required to make the model consistent with the theory of demand are:

<sup>1</sup> - Mdafri.M and Brorsen.W(1993)

$$\begin{aligned} \sum_i \alpha_i = 1, \quad \sum_i \gamma_{ij} = 0, \quad \sum_i \beta_i = 0 & \quad \text{(Adding-Up Restriction)} \quad (2) \\ \sum_j \gamma_{ij} = 0 & \quad \text{(Homogeneity)} \quad (3) \\ \gamma_{ij} = \gamma_{ji} & \quad \text{(Symmetry)} \quad (4) \end{aligned}$$

The conditions (2) and (3) are linear restrictions which may be tested by standard techniques, whereas condition (4) is imposed by the model and so is not testable. Once these restrictions are observed, system (1) characterizes a demand function system of which the sum equals total expenditure, is homogeneous of 0° in prices and expenditure, and satisfies the Slutsky symmetry propriety. Relative price variations affect demand through the parameters

Based on these specifications, a LA-AIDS model of the Iranian automotive fuel demand of three categories of fuel (gasoline, gasoil and diesel) can then be written as  $\gamma_{ij}$  a percentual variation of the jth good affects the expenditure share of ith good, holding real expenditure (X/P) constant—and variations on real expenditure affect demand through parameters  $\beta_i$ .

Based on these specifications, a LA-AIDS model of the Iranian automotive fuel demand of three categories of fuel (gasoline, gasoil and LPG) can then be written as

$$W_{it} = \alpha_i + \sum_j \gamma_{ij} \ln P_{jt} + \beta_i \ln \left( \frac{X_t}{P_t} \right) \quad (5)$$

$$W_B = \alpha_B + \gamma_{BB} \ln P_B + \gamma_{BG} \ln P_G + \gamma_{BL} \ln P_L + \beta_B \ln \left( \frac{X}{P} \right)$$

$$W_G = \alpha_G + \gamma_{GB} \ln P_B + \gamma_{GG} \ln P_G + \gamma_{GL} \ln P_L + \beta_G \ln \left( \frac{X}{P} \right)$$

$$W_L = \alpha_L + \gamma_{LB} \ln P_B + \gamma_{LG} \ln P_G + \gamma_{LL} \ln P_L + \beta_L \ln \left( \frac{X}{P} \right)$$

Where  $W_{it}$  is the consumption share of fuel i in period t, defining  $W_B, W_G, W_L; P_{jt}$  is the price of the ith good in period t, defining  $P_B, P_G, P_L; X_t$  is the total expenditure in all fuels in period t.

Marshallian elasticities are computed from the estimated parameters of the LA/AIDS model as (Hayes et al., 1990):

$$\varepsilon_{ii} = -1 + \gamma_{ii}/w_i - \beta_i \quad (6)$$

$$\varepsilon_{ij} = \gamma_{ij}/w_i - \beta_i (w_j/w_i) \quad (7)$$

The expenditure elasticities were calculated as:

$$\eta_i = 1 + \beta_i/w_i \quad (8)$$

Since the expenditure shares,  $w_i$ , add up to, the variance– covariance matrix is singular, and so the estimation requires omitting one of the share equations; after the estimation of the remaining share equations, the parameters of the omitted equation are obtained via the adding up restrictions. The technique in LA-AIDS model estimation is Zellner’s Generalized Least Square method for seemingly unrelated regression (SUR).

### 3. DATA

Time-series data for the consumption of automotive fuels in Iran are not abundant in supply. This paper has used the annual data collected by the National Iranian Oil Refining and Distribution Company (NIORDC). Table 1 shows the main descriptive statistics of the main series used in this analysis, namely, the natural log of the prices and the consumption share gasoline, gasoil and LPG. The study covers the period 1997 to 2008.

Upon inspection of the budget share estimates, it is apparent that the typical Iranian consumer allocates a higher percentage of its Fuel expenditures (with nearly 85% being distributed to gasoline) to gasoline, gasoil, and LPG and a lower percentage to LPG.

**Table 1:** Summary statistics of main variables of interest

Variable	Natural log of the price Gasoline	Natural log of the price Gasoil	Natural log of the price LPG	Expenditure-share Gasoline	Expenditure-share Gas oil	Expenditure-share LPG
Mean	6.475	4.989	4.091	0.846	0.153	0.001
Median	6.523	5.058	4.119	0.838	0.160	0.001
Maximum	6.697	5.263	4.595	0.911	0.204	0.002
Minimum	6.084	4.466	3.434	0.795	0.088	0.000
Std. Dev.	0.198	0.261	0.336	0.043	0.043	0.000

Source: own elaboration

**4. AIDS ESTIMATED RESULTS**

With homogeneity and symmetry imposed, iterated seemingly unrelated regression estimates were calculated while dropping one equation to avoid singularity of the error covariance matrix. The parameters of this omitted equation are obtained by utilizing the imposed theoretical restrictions noted above, while the selection of which equation to be omitted is irrelevant. Table 2 presents the SUR estimation results of the LA-AIDS model -as defined in (5) - with homogeneity and symmetry restrictions imposed. Empirical results indicate that some insignificant slope coefficients. This could be caused by autocorrelation, a limitation in the data used.

Table 3 and 4 present price and income elasticities calculated at the mean values of the budget shares ( $\bar{w}_i$ ) All own-price elasticities ( $\epsilon_{11}, \epsilon_{22}, \epsilon_{33}$ ) are negative, Own-price elasticities of all fuel are significant at the 5 percent level. The uncompensated own-price elasticity for LPG is -3.58, indicating that LPG consumption is sensitive to prices. Gas oil is the most price inelastic, implying that gas oil consumption is not sensitive to its price. The price elasticity of Gasoline is -1.01. Concerning the cross price elasticities, being negative, some inconsistencies are depicted, implying, a surprisingly complementarity between gasoline and gas oil.

**Table 2:** The restricted SUR estimation of the demand system equation using static LA-AIDS model.

	Parameter	Estimate	Std. Error	t-value
Cons	$\alpha_B$	-2.189	0.441	-4.957
$Ln P_{Gasoline}$	$\gamma_{BB}$	0.097	0.012	8.445
$Ln P_{Gas oil}$	$\gamma_{BG}$	-0.101	0.009	-10.657
$Ln P_{LPG}$	$\gamma_{BL}$	0.002	0.004	0.493
$Ln(X/p)$	$\beta_B$	0.120	0.019	6.285
Cons	$\alpha_G$	2.975	0.327	9.084
$Ln P_{Gasoline}$	$\gamma_{GB}$	-0.101	0.009	-10.657
$Ln P_{Gas oil}$	$\gamma_{GG}$	0.102	0.010	10.496
$Ln P_{LPG}$	$\gamma_{GL}$	-0.001	-0.007	0.162
$Ln(X/p)$	$\beta_G$	-0.111	0.014	-7.860
Cons	$\alpha_L$	0.165	0.165	1.001
$Ln P_{Gasoline}$	$\gamma_{LB}$	0.002	0.004	0.493
$Ln P_{Gas oil}$	$\gamma_{LG}$	-0.001	-0.007	0.162
$Ln P_{LPG}$	$\gamma_{LL}$	-0.003	0.003	-0.874
$Ln(X/p)$	$\beta_L$	-0.007	0.007	-0.983

Source: own elaboration.

**Table 3:** Uncompensated (Marshallian) price elasticities of Iranian automotive fuel, LA/AIDS Model

		Gasoline ( $P_1$ )	Gas oil ( $P_2$ )	LPG ( $P_3$ )
$\varepsilon_{1j}$	Gasoline	<b>-1.01</b>	-0.141	0.002
$\varepsilon_{2j}$	Gas oil	-0.046	<b>-0.22</b>	-0.006
$\varepsilon_{3j}$	LPG	7.880	0.406	<b>-3.58</b>

Note: The bold values are the own-price elasticities, the others are the cross-price elasticities.  
Source: own elaboration.

**Table 4:** The Expenditures Elasticities of the Demand System Equation using Static LA-AIDS model.

$\eta_1$	Gasoline	1.14
$\eta_2$	Gas oil	0.28
$\eta_3$	LPG	-6.21

Source: own elaboration.

## 5. CONCLUSION

The paper aimed at estimating the price and income elasticities of automotive fuels demand in Iran. The analysis of the expenditure allocation process among the gasoline, Gas oil and LPG was carried out through the estimation of a linear approximation of an AIDS model. This model is very convenient due to its ability to fulfill much of the desired theoretical properties of demand, being at the same time parsimonious regarding the number of parameters. Furthermore, the equations to be derived from LA-AIDS are linear in parameter, which allows the use of econometric methods widely available in terms of testing and estimating procedures.

Uncompensated (Marshallian) price and expenditure elasticities were calculated from estimated parameters of the LA/AIDS. The results show that all own-price elasticities are negative and statistically significant. The own-price elasticity of LPG is most elastic. Moreover, expenditure elasticities for gasoline and gas oil are positive and significant at the 5 percent significance level; the expenditure elasticity for gasoline is the most elastic. The estimations here produced suggest that LPG is inferior good. Overall this paper tried to improve the understanding of the consumer's behavior and their possibilities and criteria to choose automotive fuel in Iran.

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