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Gasoline Demand, Pricing Policy and Social Welfare in Iran

Majid Ahmadian, Mona Chitnis
and Lester C Hunt

February 2007

Department of Economics
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ABSTRACT

This study estimates a gasoline demand function for Iran using the structural time series model over the period 1968-2002 and uses it to estimate the change in social welfare for 2003 and 2004 of a higher gasoline price policy. It is found that short and long run demand price elasticities are inelastic, although the response is greater in the long run. Hence, social welfare is estimated to fall because of the higher gasoline price (ceteris paribus). However, allowing all variables in the model to change, social welfare is estimated to increase since the changes in the other variables more than compensate for the negative effects of the policy.

Gasoline Demand, Pricing Policy and Social Welfare in Iran[*]

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INTRODUCTION

Since 1982, Iranian gasoline consumption has increased faster than production. This has created disequilibrium in the gasoline market due mainly to the low price of gasoline which is determined by the government. If the price was not regulated, it is likely that the domestic price paid by Iranian consumers would be higher given prevailing world oil market prices. In order to cover the excess demand, gasoline is imported by the Iranian government at the world price and sold along with domestic production at a lower price. Consequently, government expenditure increased and potential revenue, which would have been obtained by more exports of crude oil and petroleum, decreased. In

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addition, the higher consumption of gasoline has contributed to increased environmental pollution[1].

Up until 2004, the Iranian government employed a policy of gradually increasing the gasoline price to eliminate the hidden subsidy and the perceived negative effects of the low price as outlined above.[2] This policy was employed to prevent the high negative effects of a sudden increase in the gasoline price on the Iranian inflation rate. Figure 1 shows the nominal and real gasoline price in Iran over the 1968 -2002 period. It can be seen that the nominal price in the domestic market was relatively constant until 1994 but from 1995 increased rapidly because of government policy. Whereas the real price decreased until 1979 followed by a sharp hike in 1980 followed by a decrease until 1995 when the real price started to increase slightly until the end of the period.

Figure 1: Nominal and Real Iranian Gasoline Price 1968-2002


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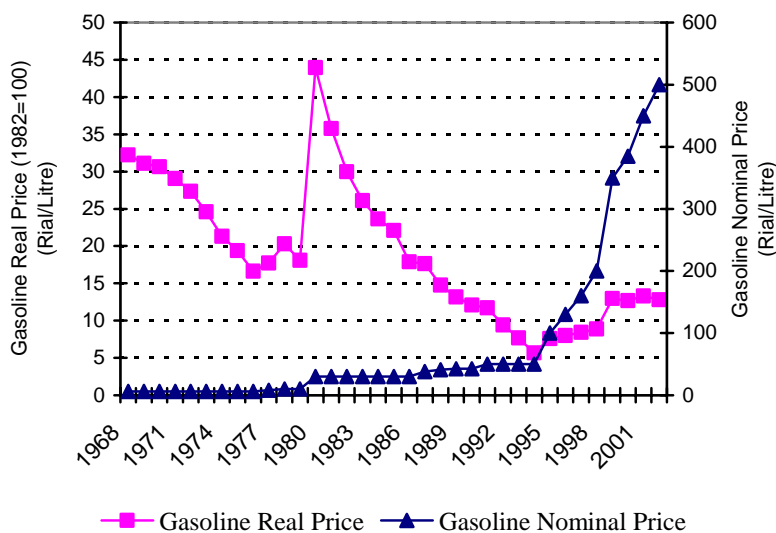
[1] Although pollution is an important factor, it is beyond the scope of the current analysis and not considered here.

[2] For example see MPO (2000).

Figure 2 illustrates the trends in Iranian gasoline production and consumption and shows that both have generally increased over the 1968 – 2002 period, however, until 1981 production exceeded consumption whereas since 1981 consumption exceeded production (hence the gap was filled by imports which have grown over this latter period). This is further illustrated in Figure 3 which gives the ratio of production to consumption over the period which decreased from 3.25 in 1968 to 0.92 in 1981 and 0.76 in 2002; perhaps suggesting that an increase in the price would help stem these developments.

Figure 2: Gasoline Production and Consumption 1968-2002
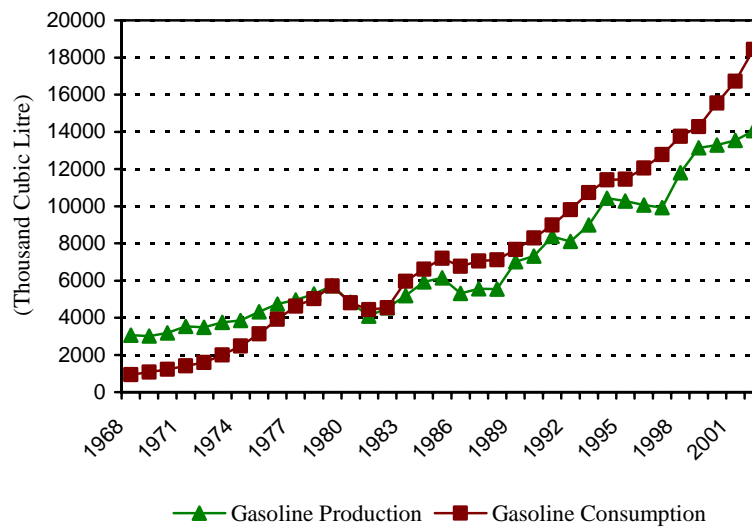
However any price increase will have an impact on the social welfare of the country, hence an understanding of the size of the impacts is important. Moreover, this should be considered along with other aspects of the policy in order to achieve the best

results. Therefore, the Iranian gasoline pricing policy is evaluated by estimating its effect

on social welfare. This is achieved by estimating an Iranian gasoline demand function

using annual time series data over the period 1968 to 2002. The structural time series

model is employed for estimation, given it allows for the estimation of a stochastic

underlying trend, since this is seen as important when estimating the gasoline price

elasticities of demand. In this framework, a deterministic trend is a special restricted case

and only accepted if is supported by the related tests in estimation.

Figure 3: The Ratio of Gasoline Production to
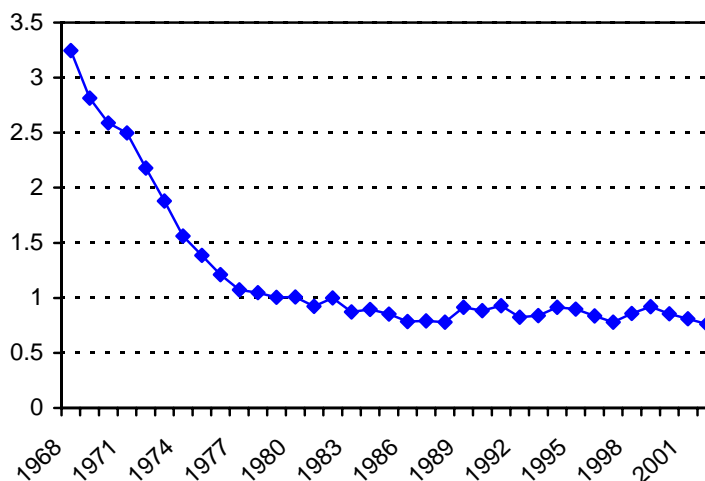*Consumption 1968-2002*

Table 1 presents some previous gasoline demand studies for Iran. All the studies

cited used annual data over a range of estimation periods and used Ordinary Least

Squares (OLS) other than Sohfi and Paknejad (2001) who used instrumental variables

(IV) with an Error Correction Model (ECM). All cited studies ignore the issue of

technical progress and underlying trends consequently none included a time trend to capture this effect. 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 (except for Gharbali Moghaddam and Eghdami, 2002 that do not include an income or activity variable in their model[3]). The estimated income elasticity for most of the cited studies is inelastic in the short run but greater, and in some cases, elastic in the long run.

No previous studies, as far as is known, have attempted to estimate the welfare effects of any policy change in the Iranian gasoline market. The next section of the paper, therefore, outlines the theoretical model for gasoline demand and supply in Iran. Section 3 introduces the empirical methodology used to estimate the demand function and calculate the effects on welfare with the results given in Section 4 and a summary and conclusion in Section 5.

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[3] Hence their results, not surprisingly, are quite different from the others.

Table 1. Some Gasoline Demand Studies for Iran

Study (year published)	Dependent variable	Technique/model used	Data used	Estimated short run elasticities	Estimated long run elasticities	Other independent variables	Notes
Gharbali Moghaddam and Eghdami (2002)	Total gasoline consumption	OLS/ Dynamic linear	annual 1966-2000	$\eta_p = -0.02$ $\eta_y = -$	$\eta_p = -0.4$ $\eta_y = -$	Dummy variable for years after revolution in Iran	Income is not included in the equation. Price elasticities are calculated by us applying the data mentioned in paper.
	Per capita consumption of gasoline	OLS/ Dynamic linear	annual 1966-2000	$\eta_p = -0.11$ $\eta_y = -$	$\eta_p = -0.03$ $\eta_y = -$	-	Income is not included in the equation. Price elasticities are calculated by us applying the data mentioned in paper.
Sohfi and Paknejad (2001)	Per capita consumption of gasoline	IV/ ECM	annual 1968-2000	$\eta_p = -0.12$ to -0.15 $\eta_y = 0.06$ to 0.27	$\eta_p = -0.59$ $\eta_y = 0.95$	-	The authors have included dependent variable lag as explanatory variables in long run equation.
Esmailnia (1999)	Per capita consumption of gasoline	OLS/ Dynamic log linear	annual 1967-1998	$\eta_p = -0.08$ $\eta_y = 0.28$	$\eta_p = -0.62$ $\eta_y = 2.15$	-	-
	Per capita consumption of gasoline	OLS/ Dynamic log linear	annual 1967-1998	$\eta_p = -0.14$ $\eta_y = 0.45$	$\eta_p = -0.48$ $\eta_y = 1.55$	-	GDP used excludes oil sector value added.
	Per capita consumption of gasoline	OLS/ Dynamic log linear	annual 1967-1998	$\eta_p = -0.08$ $\eta_y = 0.45$	$\eta_p = -0.21$ $\eta_y = 1.15$	Gasoline vehicles	-
	Per capita consumption of gasoline	OLS/ Dynamic log linear	annual 1967-1998	$\eta_p = -0.16$ $\eta_y = 0.62$	$\eta_p = -0.62$ $\eta_y = 2.38$	Gasoline vehicles	GDP used excludes oil sector value added.
	Per capita consumption of gasoline	OLS/ Dynamic log linear	annual 1967-1998	$\eta_p = -0.09$ $\eta_y = 0.59$	$\eta_p = -0.14$ $\eta_y = 0.92$	Average age of gasoline vehicles	GDP used excludes oil sector value added.

Table 1 (continued).

Akhani (1998)	Total gasoline consumption	OLS/ log linear	annual 1974-1995	$\eta_p = -0.2$ $\eta_y = 0.59$	-	-	-
	Total gasoline consumption	OLS/ Dynamic log linear	annual 1974-1995	$\eta_p = -0.1$ $\eta_y = 0.48$	$\eta_p = -0.13$ $\eta_y = 1.5$	-	-
	Total gasoline consumption	OLS/ Dynamic log linear	annual 1974-1995	$\eta_p = -0.13$ $\eta_y = 0.39$	$\eta_p = -0.21$ $\eta_y = 0.65$	Stock of gasoline vehicles	-
	Total gasoline consumption	OLS/ Dynamic log linear	annual 1974-1995	$\eta_p = -0.13$ $\eta_y = 0.47$	$\eta_p = -0.19$ $\eta_y = 0.71$	Average age of vehicles	-
	Average gasoline consumption of each vehicle	OLS/ Dynamic log linear	annual 1974-1995	$\eta_p = -0.2$ $\eta_y = 0.38$	$\eta_p = -0.28$ $\eta_y = 0.58$	Per capita vehicles	-
	Per capita consumption of gasoline	OLS/ Dynamic log linear	annual 1974-1995	$\eta_p = -0.17$ $\eta_y = 0.36$	$\eta_p = -0.28$ $\eta_y = 0.6$	Per capita vehicles	-

Note: η_p = Price elasticity, η_y = Income elasticity.

1. THEORETICAL MODEL

Demand

Following Weyman-Jones (1986), a representative demand function for gasoline can be derived by a staged procedure of utility maximization subject to the budget constraint. In the first stage, dividing goods into two groups (energy and non-energy), the consumer maximizes utility (U') subject to the budget constraint for these two goods, so that demand, and therefore expenditure, on energy goods are determined as follows:

Stage 1:

Max $\quad U'(Q_e, Q_n)$ $\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad$ **(1)**

s.t $\quad P_e.Q_e + P_n.Q_n = Y$ $\qquad\qquad\qquad\qquad\qquad\qquad\qquad$ **(2)**

giving $\quad Q_e^d = Q_e^d(P_e, P_n, Y)$ $\qquad\qquad\qquad\qquad\qquad\qquad$ **(3)**

and $\quad Y_e = P_e.Q_e^d$ $\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad$ **(4)**

where *Q, P, Y,* and Q^d represent quantity, price, income/expenditure, and demand respectively and the subscripts *e* and *n* represent energy and non-energy goods respectively.

In the second stage, dividing energy goods into four groups (petroleum, gas, electricity and coal) the consumer maximizes utility (U'') subject to the budget constraint for these four goods, so that demand and therefore expenditure on petroleum are determined as follows:

Stage 2:

Max $U''(Q_{pe}, Q_{ga}, Q_{el}, Q_c)$ **(5)**

s.t. $P_{pe} . Q_{pe} + P_{ga} . Q_{ga} a + P_{el} . Q_{el} + P_c . Q_c = Y_e$ **(6)**

giving $Q_{pe}^d = Q_{pe}^d (P_{pe}, P_{ga}, P_{el}, P_c, Y_e)$ **(7)**

and $Y_{pe} = P_{pe} . Q_{pe}^d$ **(8)**

Where *U''* represents stage 2 utility and the subscripts *pe*, *ga*, *el* and *c* represent petroleum, gas, electricity and coal respectively.

In the third stage, dividing petroleum into three goods (gasoline, kerosene and diesel) the consumer maximizes utility (*U'''*) subject to the budget constraint for these three goods, so that demand and therefore expenditure on gasoline are determined as follows:

Stage 3:

Max $U'''(Q_g, Q_k, Q_d)$ **(9)**

s.t. $P_g . Q_g + P_k . Q_k + P_d . Q_d = Y_{pe}$ **(10)**

giving $Q_g^d = Q_g^d (P_g, P_k, P_d, Y_{pe})$ **(11)**

where the subscripts *g*, *k* and *d* represent gasoline, kerosene and diesel respectively.[4]

From the above derivation, it can be seen that in general the demand for gasoline is expected to be a function of the gasoline price, the kerosene price, the diesel price and the expenditure on petroleum products. However, in the estimation

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[4] Given the nature of the application of fuel oil which is consumed by the industrial sector as an input, this petroleum product is ignored in the third stage of the utility maximization procedure; implicitly assuming that the demand for fuel oil is derived by cost minimization subject to a production constraint by producers.

detailed below GDP replaces expenditure on petroleum products given the analysis is for whole economy aggregate gasoline consumption, and the lack of data for petroleum product expenditure. In addition the price of kerosene is ignored in the estimation since kerosene is primarily used for heating and hence neither a substitute nor a complement for gasoline.

Supply

The Iranian petroleum products industry, including gasoline, is run by a number of (non-profit maximising) public refinery companies that administer the price of gasoline set each year by the government. In addition, the Iranian government determines the amount of crude oil each year that is used by the refineries in order for them to produce petroleum products, including gasoline. Therefore, annual Iranian gasoline supply is assumed to be vertical at the level of production and hence perfectly price inelastic as follows:

$$Q_{gt}^s = \overline{Q}_{gt}^s \qquad\qquad (12)$$

where Q_{gt}^s and $\overline{Q}_{gt}^s$ represent gasoline supply and gasoline production respectively. Hence, although the supply function is vertical, it is likely to shift over time due to changes in the amount of crude oil input into the refining process (as set by the government); in addition to other exogenous factors.[5]

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[5] Amongst other things, this could include such exogenous factors as changes in technology, expansion of the size of plant, efficiency improvements, outages due to maintenance, etc.

2. EMPIRICAL METHODOLOGY

Demand

To estimate the gasoline demand function for Iran, the structural time series model (STSM) is applied (see Harvey 1989). This allows for the estimation of a stochastic rather than a deterministic underlying trend, which arguably is important when estimating the gasoline price elasticity of demand as discussed by Hunt and Ninomiya (2003). In addition to technological advance, the underlying trends could be strongly affected by changes in tastes, consumer preferences, socio-demographic and geographic factors which are not easily measured, and therefore difficult to obtain any suitable data. Hence the inclusion of the stochastic trend in the following long run gasoline demand model:

$$q_{g\,t}^{d} = \mu_t + z_t'\delta + \varepsilon_t \qquad \varepsilon_t \sim NID(0, \sigma_\varepsilon^2) \tag{13}$$

where $q_{g\,t}^{d}$ is the gasoline consumption (in natural logs), μ_t represents the trend component, z_t is a $k \times 1$ vector of other independent variables - including the real gasoline price (rp_g) and GDP (y) both in natural logs - δ is a $k \times 1$ vector of unknown parameters and ε_t is a random white noise disturbance term.

The trend component μ_t is assumed to have the following stochastic process:

$$\mu_t = \mu_{t-1} + \beta_{t-1} + \eta_t \qquad \eta_t \sim NID(0, \sigma_\eta^2) \tag{14}$$

$$\beta_t = \beta_{t-1} + \xi_t \qquad \xi_t \sim NID(0, \sigma_\xi^2) \tag{15}$$

so, the trend includes a level and a slope which is β. The nature of the trend depends on the variances σ_η^2 and σ_ξ^2, known as hyperparameters. At the extreme, if they are both equal to zero, the model will collapse to the conventional model with a deterministic linear trend as follows:

$$q^d_{g_t} = \alpha + \beta t + z'_t \delta + \varepsilon_t \qquad (16)$$

The Maximum Likelihood (ML) procedure in conjunction with the Kalman filter is used to estimate an Autoregressive Distributed Lag (ARDL) form of equation (13)[6] using the software STAMP6.3 (Koopmans, et al., 2000). This general function is considered initially and the preferred model found by testing down from the over parameterised ARDL model subject to a battery of diagnostic tests.[7]

Welfare

The estimated demand function along with the assumed vertical supply curve are used to calculate the welfare changes of a gasoline price increase at two levels. At the first level, the '*pure price effect*' of a higher gasoline price on welfare in 2003-2004, holding other variables (such as GDP, etc.) constant is calculated as follows:

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[6] Starting with lags of three years.

[7] For further details refer to Hunt and Ninomiya (2003). The cointegration approach is not considered here since it only allows for a deterministic trend and not a stochastic trend; whereas, the STSM can accommodate a stochastic trend which is consistent with the interpretation of underlying trends of Hunt and Ninomiya (2003). Therefore, a deterministic time trend is a limiting case of the STSM, which is admissible only when statistically accepted by data.

$$\Delta CS^1 = -\int_{p_{g03}}^{p_{g04}} Q_g^d(\mu_{03}, Z_{03}, P_g) d_{p_g} \tag{17}$$

$$\Delta PS^1 = (P_{g04} - t_1 P_{g04})Q_{g03}^s - (P_{g03} - t_{03}P_{g03})Q_{g03}^s = Q_{g03}^s(P_{g04} - P_{g03})(1 - t_{03}) \tag{18}$$

$$\Delta SS^1 = \Delta CS^1 + \Delta PS^1 \tag{19}$$

where CS, PS and SS represent consumer surplus, producer surplus and social surplus respectively.[8] Also, Q_g^d and Q_g^s denote gasoline demand and supply respectively. P_g is the nominal gasoline price and t is the gasoline tax rate. Subscripts 03 and 04 indicate the values in years 2003 and 2004 respectively and superscript 1 denotes the first level, '*pure price effect*'.

At the second level, the '*overall effect*' is calculated. In addition to the change in the gasoline price, the other variables that drive demand (held constant for the first level such as GDP, CPI, the underlying trend, etc.) are also allowed to vary thus allowing the demand curve to shift between the two years. Furthermore, the vertical supply curve, fixed in the first level, also shifts out slightly primarily due to changes in the level of crude oil used by the public refineries.[9] Therefore the second level '*overall effect*' calculates the changes in welfare resulting from the movement along the gasoline demand curve (the '*pure price effect*') plus changes in welfare resulting from a shift in the demand curve and the vertical supply curve; thus giving an estimate of the change in total welfare between the two years 2003 and 2004.

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[8] Strictly speaking, the correct measures of consumer welfare change are compensating variation (CV) or equivalent variation (EV). However, the differences between consumer surplus, CV and EV measures are very small hence the consumer surplus measure is applied here.

[9] Although part of the shift in the supply curve might have occurred due to some of the exogenous factors identified in footnote 5 above.

Consequently, the change in consumer surplus from allowing for a *shift* in the demand curve is as follows:

$$\int_{p_{g04}}^{p_{gN}} Q_g^d(\mu_{04}, Z_{04}, P_g) d_{p_g} - \int_{p_{g04}}^{p_{gO}} Q_g^d(\mu_{03}, Z_{03}, P_g) d_{p_g} \qquad (20)$$

and the change in producer surplus after also allowing for a shift in the vertical supply curve is as follows:

$$(Q_{g04}^s - Q_{g03}^s)(P_{g04} - P_{g04} t_{04}) = P_{g04}(Q_{g04}^s - Q_{g03}^s) P_{g04}(1 - t_{04}) \qquad (21)$$

where P_{gN}, P_{gO} are the prices which the quantity of demand is equal to zero after and before a shift in demand curve respectively. Other definitions are the same as above. Adding equations (20) and (21) to equations (17) and (18) respectively, the overall welfare changes are calculated as follows:

$$\Delta CS^2 = -\int_{p_{g03}}^{p_{g04}} Q_g^d(\mu_{03}, Z_{03}, P_g) d_{p_g} + \int_{p_{g04}}^{p_{gN}} Q_g^d(\mu_{04}, Z_{04}, P_g) d_{p_g} - \int_{p_{g04}}^{p_{gO}} Q_g^d(\mu_{03}, Z_{03}, P_g) d_{p_g} \quad (22)$$

$$\Delta PS^2 = Q_{g04}^s P_{g04}(1 - t_{04}) - Q_{g03}^s P_{g03}(1 - t_{03}) \qquad (23)$$

$$\Delta SS^2 = \Delta CS^2 + \Delta PS^2 \qquad (24)$$

where superscript 2 denotes the second level, '*overall effect*'.

Data

The initial general ARDL demand relationship as outlined above is estimated using data over the period 1968 to 2002 and the welfare calculations are undertaken for the period 2003 to 2004. The data used are annual time series of gasoline consumption in natural logarithms for the dependent variable (q_g^d), and the real GDP, real gasoline price, real diesel price, population, and the stock of vehicles all in natural logarithms as the independent variables (z').

Data were collected from the National Iranian Oil Refining and Distribution Company (NIORDC), the Ministry of Energy, the Management and Planning Organization (MPO), the Central Bank of Iran, the Ministry of Industry and the Islamic Republic of Iran Police. Population used is the prediction of the MPO for the 3rd economic, social and cultural development plan. The stock of vehicles is approximately calculated as the production of gasoline using vehicles plus imported gasoline using vehicles each year minus or plus the number of such vehicles registered by the police in the year 2000. Nominal gasoline prices are deflated by the Consumer Price Index (CPI).

3. RESULTS

Demand

The model was estimated for gasoline demand for Iran for the period 1968 to 1998; saving 4 years for post sample prediction tests. By testing down from a general ARDL version of equation (13) with a three year lag a suitable restricted model for Iranian gasoline demand was selected by eliminating insignificant variables in order to determine the number of lags, included variables and the nature of the trend, but ensuring a range of diagnostics tests were passed. The preferred equation is given in Table 2 which shows that the model fits the data well passing all diagnostic tests indicating that there are no problems with residual serial correlation, non-normality or heteroscedasticity. Furthermore, the auxiliary residuals are found to be normal and the model is stable as indicated by the post sample predictive failure tests.[10]

The estimated short run and long run price elasticities are -0.19 and -0.74 respectively and the estimated short run and long run income elasticities are 0.32 and 1.25 respectively. Hence, estimated long run elasticities are greater than the short run (in absolute terms) however with respect to the price, gasoline demand is inelastic in both the short- and the long run whereas with respect to income demand is inelastic in the short run but elastic in the long run. Furthermore, the results are consistent with the previous studies for Iran highlighted in Table 1, despite the different estimation method.

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[10] Following Harvey and Koopman, (1992) intervention dummies were added for significant outliers in the years 1983 and 1986 to ensure all diagnostic tests were passed, but their inclusion has no discernable effect on the estimated coefficients.

The Likelihood Ratio (LR) test in Table 2 implies that imposing the restriction of a deterministic trend (where both the level and the slope in the trend are fixed) is rejected. Therefore, the trend in the preferred model, presented in Figure 4[11], is the local level with drift specification where the trend is stochastic in the level but fixed in the slope. It can be seen that the underlying trend is clearly non-linear, generally increasing between 1968 to 1985 followed by a substantial decline between 1985 to 1995 before increasing again after 1995. This implies that from 1985 to 1995 gasoline intensity in Iran was generally falling, hence shifting the demand curve to the left (*ceteris paribus*), in contrast to the rest of the estimation period. In particular, since 1995 where the underlying trend suggests that intensity fell quite fast with the gasoline demand curve shifting outwards (*ceteris paribus*). One possible explanation for this is that over this period there was a fast increase in car production and purchases with convenient buying conditions for customers such as payment instalments and affordable car prices for consumers.

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[11] The trend for the estimated equation over the whole period, up to and including 2002 (given in the final column of Table 2) is actually presented given this equation is the one used for the welfare calculations later in the paper.

Table 2: Estimated STSM Gasoline Demand Functions for Iran

Dependent variable: Gasoline consumption (in logs) - q_g^d		
VARIABLES	1968-1998	1968-2002
y	0.32 (3.03)	0.35 (3.48)
$q_g^d(-1)$	0.74 (8.68)	0.72 (8.91)
rp_g	-0.19 (4.87)	-0.18 (4.99)
$d1983$	0.07 (5.15)	0.07 (5.25)
$d1986$	-0.05 (3.79)	-0.05 (3.80)
Long run Elasticities		
Price	-0.74	-0.63
Income	1.25	1.25
Estimated Variance of Hyperparameters		
Irr (10^{-5})	0.00	0.00
Lvl(10^{-5})	27.93	25.86
Nature of Trend	Local level with drift	Local level with drift
DIAGNOSTICS		
Equation Residuals		
Std. Error	0.02	0.01
Normality	0.96	0.51
$r_{(1)}$	0.00	0.04
$r_{(2)}$	0.15	0.19
$r_{(3)}$	-0.23	-0.14
D.W.	1.94	1.91
$Q_{(7,6)}$	5.42	5.97
R^2	0.87	0.86
Auxiliary Residuals		
Irregular		
Skewness	0.00	0.07
Kurtosis	0.00	0.90
Normal-BS	0.00	0.97
Normal-DH	0.95	4.24
Level		
Skewness	0.04	0.27
Kurtosis	0.93	0.53
Normal-BS	0.97	0.80
Normal-DH	0.59	0.55
Predictive Failure Tests		
$\chi^2_{(4)}$	1.92	n/a
Cusum $t_{(4)}$	1.06	n/a
Likelihood Ratio Test		
$\chi^2_{(1)}$	16.52	18.83

Notes for Table 2:

q_g^d , y and rp$_g$ represent gasoline consumption, income and the real price of gasoline (all in logs). d represent intervention dummies.

t-statistics are given in parenthesis.

The restriction imposed for the LR test is the fixed level and fixed slope (conventional model).

Normality is the Bowman-Shenton and Doornik-Hansen statistics approximately distributed as $\chi^2_{(2)}$.

Skewness and Kurtosis statistics are approximately distributed as $\chi^2_{(1)}$.

H$_{(9/11)}$ is the test for heteroscedasticity, approximately distributed as $F_{(9,9)} / F_{(11,11)}$.

r$_{(1)}$ to r$_{(4)}$ are the serial correlation coefficients at the 1st to 4th lags respectively, approximately distributed at N(0,1/T).

DW is the Durbin Watson statistic.

Q$_{(n,6)}$ is the Box-Ljung Q-statistic based on the first n residuals autocorrelation; distributed as $\chi^2_{(6)}$.

R^2 is the coefficient of determination.

$\chi^2_{(4)}$ is the post-sample predictive failure test.

The Cusum t is the test of parameter consistency, approximately distributed as the t-distribution.

Figure 4: Estimated Underlying Gasoline Demand Trend 1968-2002
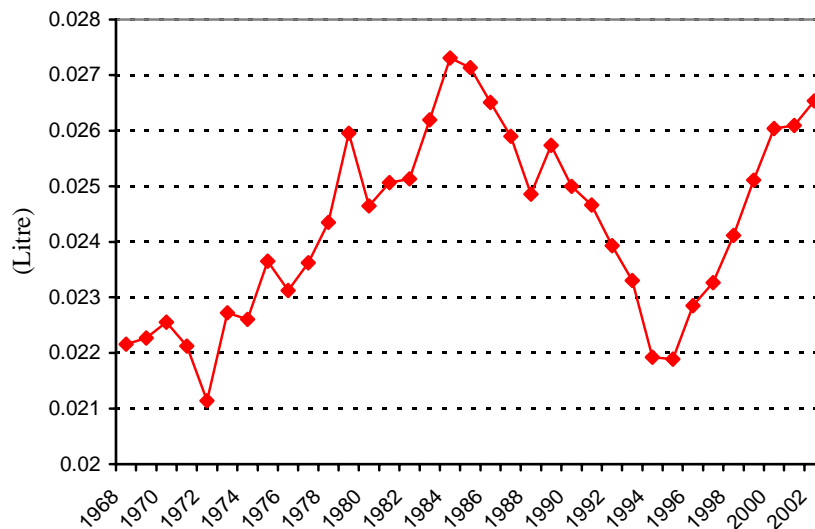
Focussing on the final preferred specification in Table 2 it can be seen that the only lag significant, and hence retained, is the first lag of gasoline consumption. The diesel price (as a substitute for gasoline) was not significant in the model and so was

omitted. When either the stock of vehicles or population or both were added to the model, the LR test implied that the restriction of a deterministic trend could not be rejected. Therefore, the equation including either stock of vehicles or population or both were estimated with a fixed level and fixed slope (i.e. the conventional deterministic model), but these gave unreasonable price and income elasticity estimates; both elasticities being regarded as too small in the long run when the stock of vehicles and/or population were added and the long run income elasticity regarded as too high when just population was added. In addition, a general per capita demand function for gasoline consumption was also estimated with the preferred equation giving results very similar to the total demand function for gasoline consumption, with similar values of coefficients – highlighting the robustness of the results.

The final column of Table 2 gives the results from re-estimating the preferred model over the whole sample period 1968 to 2002. It can be seen that the results are extremely similar, again highlighting the robustness of the results.

Welfare

In order to calculate the welfare changes the estimated gasoline demand function for the full sample period, given in Table 2, was used to calculate the welfare changes at two levels as explained in section 3 above.

The results for the '*pure price effect*' with the change in consumer and producer surplus expressed as shares of the total social welfare change are given in Table 3. This shows that the change in consumer welfare was found to be negative

and relatively large when compared to positive, but relatively smaller, producer welfare component.

In order to calculate the '*overall effect*' the price for which the quantity of demand would be equal to zero is needed, before and after the shift in the demand curve i.e. P_{g_N}, P_{g_O} in equation (22). Given, the demand curve is estimated in linear-logarithm form, it is a non-linear multiplicative function after taking anti-logarithms. But in order to calculate the welfare changes the level form is required in order to integrate the function in price and quantity space. But given the non-linear multiplicative nature of the function it means that for the demand curve, as the quantity of consumption approaches zero, the price approaches positive infinitely. Hence, the non-linear demand curve never actually touches the price axis. Moreover, the limit of the integral in equation (22) when price tends to positive infinity is again positive infinity, so it is not possible to get a definite amount for this part of the change in consumer welfare. To solve this problem, some assumptions are made to consider a high price for Iran where the consumption would be expected to be close to zero.[12]

The estimated '*overall effect*' is therefore given in the final column of Table 3. This shows that increases in GDP, CPI and the trend component have a large effect

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[12] Due to availability of data and since the UK gasoline market is competitive and prices are market determined and generally higher compared to most other competitive gasoline markets in other countries (such as the US) due primarily to high taxation rates, UK gasoline price data from 1977 to 2003 weighted by gasoline consumption was used as a benchmark. Data came from the Digest of UK for Energy Statistics (DUKES) and www.dti.gov.uk/energy/statistics/publications/prices/tables/page18125.html (table 4.1.2). It was assumed that the data is normally distributed, so the upper limit of $\overline{P} + 3\sigma$ was used as an upper limit of integrals in equation (22) for P_{g_N} and P_{g_o} (where $\overline{P}$ and σ are the average and standard deviation of UK prices respectively).

on the change in consumer welfare, more than compensating the negative effect of the higher gasoline price. Furthermore, the change in producer welfare is still positive, but somewhat smaller than the positive change in consumer surplus. However, it should be stressed that these results for consumer welfare are only an estimation; however they do give a good indication of the direction and approximate relative sizes of the change in welfare.

Table 3: The 'Pure Price Effect' and 'Overall Effect'
of a Higher Gasoline Price on Welfare
(relative changes from 2003 to 2004)

Percentage shares

Title	Relative Changes	
	Pure Price Effect	*Overall Effect**
Consumer Surplus	-137.4	+96.3
Producer Surplus	+37.4	+3.7
Social Loss/Benefit	-100	+100

*In order to check the sensitivity of the change in overall welfare estimates to the assumptions for P_N and P_O, a lower price of $\overline{P} + \sigma$ (see footnote 12) was also used, but this had no discernable affect in the welfare calculation.

Consequently, for the '*pure price effect*' results in an estimated social loss suggesting that the positive effects of the policy not big enough to compensate for the negative effects. However, this is only the direct effect of the higher gasoline pricing policy, so that when also considering the effects of changes to the other variables, the '*overall effect*', estimated social gain is high and positive.

4. SUMMARY AND CONCLUSION

In this paper, an attempt has been made to discover the effect on social welfare of the gasoline pricing policy in Iran. This was achieved by firstly estimating a gasoline demand function for Iran with an allowance for a stochastic underlying energy demand trend by applying the structural time series model. The preferred gasoline demand model includes a local level with drift trend and is inelastic with respect to price both in the short and long run, but with the response greater in the long run.

From this, estimated changes in social welfare were calculated due to a higher gasoline price for 2003 and 2004. Holding all other variables constant, it was shown that the estimated effect of only raising the gasoline price results in a reduction in welfare. That is, although there are some positive effects from the policy, these are outweighed by the negative effects. However, estimated changes in social welfare when allowing all variables in the model to change, is positive due to high positive changes in consumer surplus brought about by the rise in GDP, etc. which is shifting the demand curve outwards. This implies that the direct negative effect of an increase in the gasoline price for consumer is likely to be more than compensated by increases in these other variables. Therefore, given the size of the estimated long-run income elasticity, during a period of growing GDP would appear to be the most advantageous time to introduce the policy of higher Iranian gasoline prices.

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