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Executive Summary

Like most other petroleum-exporting countries Iran subsidizes domestic consumption of refined products. Real product prices have declined for the past 25 years while the rest of the world has adjusted to higher energy prices. In this paper I describe the market for petroleum products in Iran and estimate demand functions for the four main refined petroleum products. My results indicate that price elasticities of demand are larger than previously thought. Particular attention is paid to the kerosene market where price subsidy is the largest, and where rationing in the 1980s requires taking into account the working of the black market. The results indicate that price increases can stem the rise in consumption. Forecasts show that, allowing for modest economic growth, increases that bring domestic prices to the level of world prices in fifteen years, will stabilize consumption at its current level. But increases that merely keep real prices constant will double consumption in the same period. This is significant in light of the fact that Iran's production capacity has stayed constant in the last five years and exports are under increasing pressure from domestic consumers of refined products.

I. Introduction

Oil-exporting countries are among the world's fastest growing consumers of petroleum products. Between 1966 and 1986, encouraged by rising incomes and falling prices, domestic consumption of oil in OPEC countries increased by 94 per cent per year. Without further increase in capacity, at this rate their consumption of refined products - which in 1993 stood at 15 per cent of oil production capacity - could exceed 50 per cent in fifteen years, thus displacing the rest of the world as the main consumer of OPEC oil. In some countries - for example, Iran, Indonesia and Nigeria - domestic consumption has already reached one-third of production, and unless checked it may outgrow planned expansion in capacity. Serious difficulties in financing the building of new capacity have prompted many countries to try to restrain domestic consumption in order to free more crude oil for exports. Increased awareness of environmental costs arising from inefficient use of oil products has also strengthened conservationist policies in oil-exporting countries.

This paper is a case study of pricing of and demand for petroleum products in Iran. Iran heavily subsidizes the consumption of these products. Government attempts to remove the subsidy have faced political opposition. In March 1995 prices for basic petroleum products were doubled, but they are still far below world market prices, and are falling in real terms because of inflation. Further increases are planned, but inflation is likely to render them ineffective as soon as they are implemented. Official claims regarding savings as a result of the price increase in March are in the order of 10 per cent inconsumption, but the decline may be due to general economic slowdown. In the absence of information about price and income elasticities, we do not know how much of the decrease should be attributed to increases in price and how much to slower growth in income. In this paper I report on the estimation of demand functions for the four main petroleum products that help in resolving such questions. I use the estimated elasticities to forecast consequences of future price policies.

My estimates fall within the range of elasticities reported for other countries.[1] Though they indicate only moderate responsiveness of consumption to price, given the enormous size of the existing subsidies, significant distortions should be expected. The larger income elasticities are signs of future difficulties: economic growth will worsen the balance between domestic use and exports of oil production. The policy of raising prices offers itself as a solution to the dilemma of growth and demand restraint. But, given the social costs of higher prices in terms of access to heating, transportation, and cooking by the poor, it is important to know whether higher prices can indeed restrain demand.

By implication, this paper also addresses ominous questions raised for the world oil market. Given the perception of abundance of oil, oil-exporting governments face enormous political and social pressures not to raise prices of refined products. With near unity income elasticity and non-negligible responsiveness of demand to price, consumption in oil-exporting countries should grow rapidly. On the other hand, in recent years financing problems have prevented many countries from investing in the expansion of production capacity. As a result, in the next century world supply of petroleum will come under serious squeeze as oil-exporting countries divert oil from exports to meet domestic demand.

II. Domestic Pricing Policy

Until they doubled in March 1995, domestic prices of refined products had changed very little from their values in 1960, thus registering huge declines in real terms (see Figures 1 and 2). In 1933, the Anglo-Iranian Oil Company sold refined products in Iran at world prices; in 1994 they were only 2 per cent of world prices. In 1995 the stated objective of the government is to create parity between domestic and world prices of petroleum products. It has several reasons for doing so:

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[1] For references and review of literature on energy demand functions for less developed countries in general, see Dahl (1991). See also Choucri (1985).

Nominal prices of refined products, rials per liter, 1964–1993

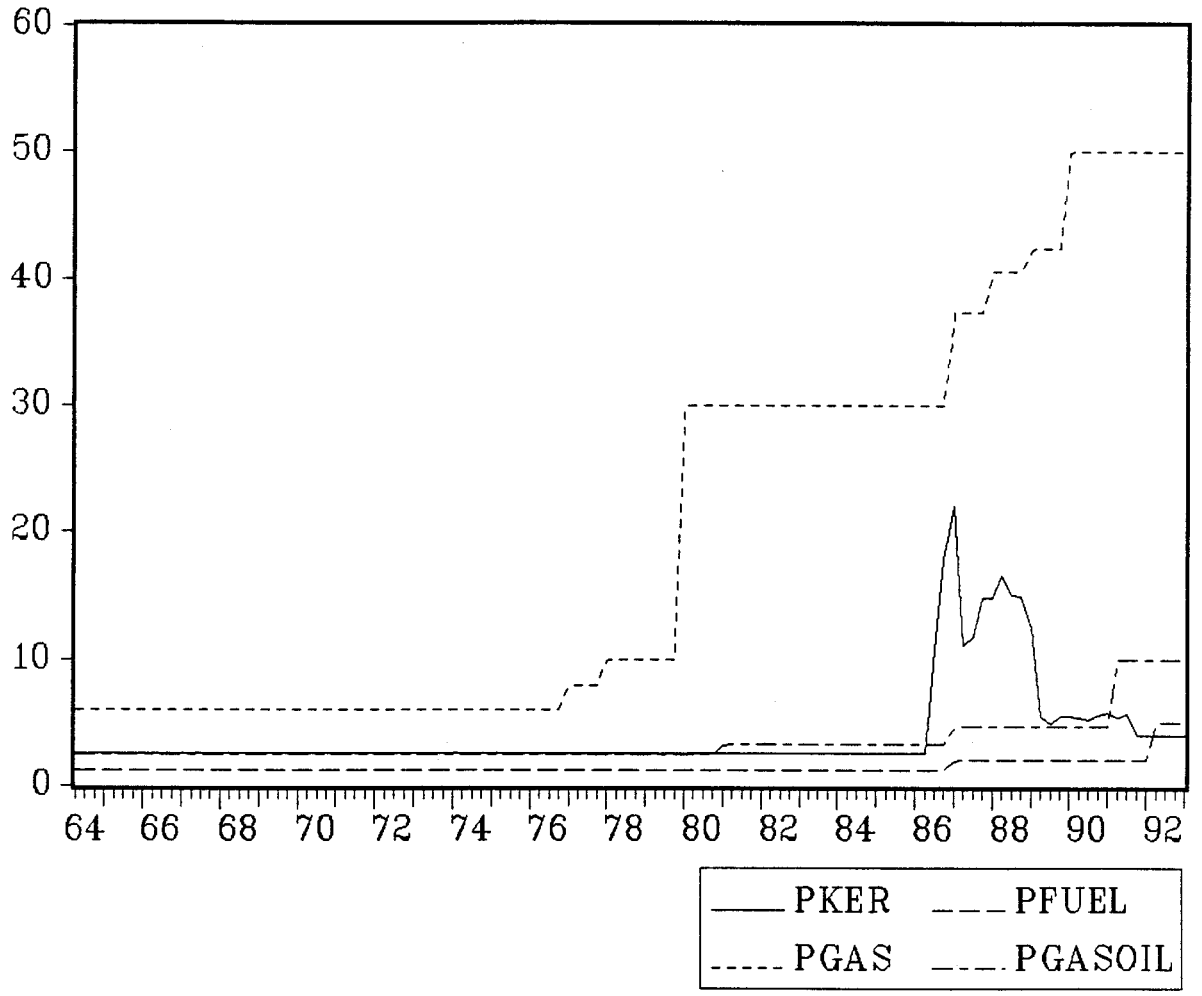

Figure 1

Real prices of refined products, 1964–93

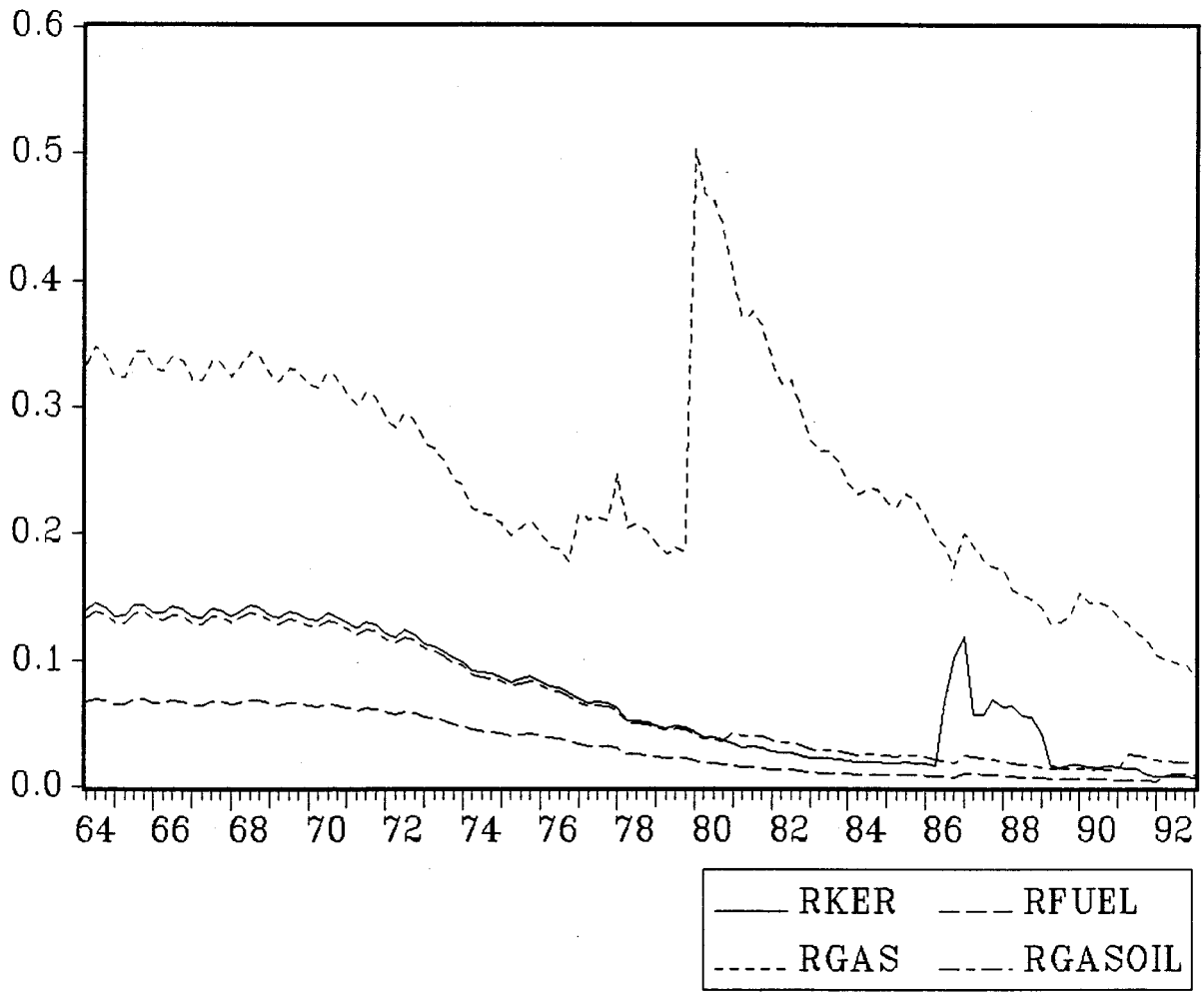

Figure 2

The Petroleum Subsidy

In 1993/94 Iran's production and capacity were about 3.9 million barrels per day (mb/d). Of this amount about 1.1 million barrels per day were refined and consumed domestically, and an additional 152 thousand barrels daily (tb/d) were imported, leaving about 2.6 mb/d for revenue-earning exports.[2] Instead of earning about $6 billion from the domestic sales of petroleum products, the government actually loses money. The Ministry of Oil maintains that prices barely pay for the cost of distribution. In 1993, during a brief period when there was only one exchange rate and it was therefore straightforward to compute dollar values for domestic prices, the average price per barrel of product sold in Iran was about 2000 rials or $1.3. Assuming, conservatively, a shadow price of $13 per barrel for the average barrel of refined products, the subsidy is estimated at $5 billion.[3]

The significant difference between the petroleum subsidy and the subsidy for food and medicine which claimed about $3.2 billion in 1993/94 is that the former is income foregone rather than actual payment. In reality there is no difference between the two; the government could in principle balance its budget with an additional $5 billion in revenue as by cutting that much from expenditures. However, politically, as the sole supplier of refined products, the government has a hard time convincing the people, and the Parliament, that it should charge world prices for what most Iranians see as an abundant commodity.

Competition of Domestic Demand With Exports

Thanks in no small part to falling product prices in real terms (see Figures 1 and 2), consumption of petroleum products has increased rapidly, averaging 9 per cent for the past 28 years. For the fifteen years before the revolution this rate was 12.6 per cent per year, falling drastically to 4.8 per cent in the 1980s, during a period of no real economic growth and rationing of demand. But when economic growth resumed, at the rate of 7.1 per cent during the First Five-Year Plan (1988-93), the rate of increase jumped to 6.3 per cent per year.[4] According to the First Plan Performance Report, in 1993/94 Iran used 1167 tb/d of crude for domestic refinery throughput and swapped an additional 280 tb/d for imported refined products, for a total of 1.45 mb/d, or 37 per cent of domestic production. If it were to continue to grow at this rate, by the year 2010 consumption would exceed current capacity and there would be no room for exports. Put another way, given that capacity cannot increase at this rate, unless consumption is curtailed, Iran will cease to be an oil-exporting nation in the next 15 years. During the First Development Plan (1989-93) Iran spent 4087.9 billion rials on investment in the oil sector (approximately $10 billion) to increase its capacity by about 1.5 mb/d. The Second Plan does not have provision for further increases in capacity, so the race between domestic consumption and exports has entered a serious phase.

The First Plan ignored price adjustment as a means to control consumption and instead relied entirely on the substitution of natural gas for refined products. The government embarked on an ambitious plan to expand production and the distribution network of natural gas. During the Plan, production of natural gas increased by 10.3 per cent per year, from 137.2 million cubic metres (mcm) per day in 1989/90 to 224.1 in 1993/94; refining capacity increased from 39.1 mcm per day to 94.0 mcm/day, and the number of households hooked up to the network went up from 1.3 million to 4 million. In the future it will be hard to surpass or even maintain such rates of expansion of the gas network. Therefore, the 6.3 per cent increase in consumption of refined products is not

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[2] *The Statistical Yearbook of Iran, 1372 (1993-94)*, Statistical Centre of Iran, 1995, pp. 146-152. The original source is quoted as the Ministry of Oil. The production figure of 3.9 mb/d is 250 tb/d in excess of Iran's OPEC quota, which is calculated for the Georgian calendar year rather than the Iranian year quoted here.

[3] Under the multiple exchange rate system of 1995 the calculation of the dollar amount is less straightforward. In speeches government officials have quoted much higher figures, as high as $11 billion. I regard that as an exaggeration.

[4] Plan and Budget Organization, *Performance of the First Five Year Plan 1994*.

likely to fall on account of substitution. It is perhaps with this realization that the Second Five-Year Plan included provisions for price increases.

Joining the World Trade Organization

Iran's overall development strategy in the post-war period is to shift from import substitution to export oriented growth. But the policy of promoting non-oil exports can only succeed in the long run if the country's goods can enter the world market without facing stiff trade barriers. This requires joining the World Trade Organization as a signatory to the GATT agreements. The government is aware of this and several government officials have spoken to this effect.

But at present Iran's ubiquitous energy subsidies pose a serious problem in any future negotiations for Iran's entry into the World Trade Organization. Removing petroleum subsidies is therefore a precondition for the promotion of non-oil exports and the success of the export oriented strategy.

III. Demand and Supply

Iran is richly endowed with oil and gas reserves. With a share of 1 per cent in the world population its share in total world reserves of oil and gas are 5 per cent and 14 per cent respectively. The government is by far the major supplier of energy, producing over 95 per cent of all energy supplied. The National Iranian Oil Company (NIOC) is responsible for supply of all petroleum products, it operates several refineries and imports refined products to meet local demand.[5] In the past Iran has been at times a net exporter of refined products, but since the destruction of the Abadan refinery in 1980 by Iraqi artillery, it has consistently imported an average of about 150 tb/d per year.[6]

Table 1: Sources of Supply of Primary Energy
(Million Barrels Oil Equivalent)

	1967	*1972*	*1977*	*1982*	*1987*	*1989*
Oil products	59.5	82.8	186.7	208.6	298.5	316.2
Natural gas	5.0	10.1	20.0	43.3	69.0	96.2
Solid fuels	5.5	6.2	12.0	12.4	9.5	8.6
Hydro	1.0	5.5	6.6	10.1	13.1	11.7
Total	71.0	104.6	227.3	274.4	390.1	432.7

Source: Plan and Budget Organization, Tehran.

Although consumption of petroleum products has grown very fast, their share in total energy supply has declined over the years owing to rationing in the 1980s and increased supply of natural gas (see Table 1). In 1989 petroleum products accounted for 73 per cent of total energy demand, compared to 83 per cent in 1967. Natural gas increased its share from 1 per cent to 22 per cent in the same period.

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[5] For the energy picture in Iran before the revolution see F. Fesharaki (1976), and Mossavar-Rahmani (1981).

[6] In 1995, reports indicate that Iran has considerably reduced its import of products. Increased domestic prices and expansion of the gas network are cited as reasons for reduced imports.

Rationing and a declining economy only slowed down the pace of increase in consumption of petroleum products in the 1980s. While GDP in 1989 was 12 per cent below its real value in 1977 consumption of petroleum products was up by 78 per cent (see Table 2 and Figure 3), even outpacing population which grew by about 40 per cent between the same years. Energy efficiency has declined for the past twenty years. Between 1972 and 1989 a period of rising world energy prices, energy intensity (defined as the ratio of refined product consumption to GDP) doubled in Iran while in OECD countries it fell by nearly one-quarter. Moreover, Iran was already using more energy per unit of production in 1972 than the average for OECD: 5.9 barrels per $1000 of non-oil GDP (5.2 barrels per $1000 of GDP) compared to 4 barrels for OECD.[7]

Table 2. Consumption of Petroleum Products and GDP in Iran
(1000 Barrels per Day, and Billion 1974 US Dollars)

Year	*GDP*	*Total*	*Fuel oil*	*Gasoil*	*Gasoline*	*Kerosene*	*Other*
1965	17.1	105.8	31.0	28.9	13.1	25.5	7.2
1970	28.3	183.3	55.7	53.6	22.2	39.9	12.0
1975	45.0	363.9	88.6	105.9	50.9	74.4	25.3
1976	50.4	438.5	111.3	111.3	68.1	93.0	54.8
1977	51.3	496.0	107.0	157.0	80.3	105.0	46.8
1978	45.7	517.5	106.3	165.5	87.5	104.8	53.5
1979	43.9	550.5	113.6	164.3	99.4	127.8	45.6
1980	36.6	509.5	124.8	158.8	82.3	100.3	43.5
1981	37.7	530.0	145.8	170.8	76.5	91.5	45.5
1982	43.4	581.3	147.3	196.8	78.3	107.0	52.0
1983	48.8	710.3	168.8	234.8	102.0	140.3	64.5
1984	48.2	762.0	187.5	251.3	112.8	138.5	72.0
1985	50.2	853.5	205.3	296.5	123.3	143.5	85.0
1986	46.2	782.8	213.3	279.5	115.8	103.3	71.0
1987	45.3	806.0	186.3	293.8	121.3	126.5	78.3
1988	42.7	839.8	205.9	298.8	122.5	128.5	84.0
1989	44.2	881.2	196.9	302.5	131.2	153.3	97.3
1990	48.9	918.3	210.8	325.7	141.3	145.6	95.0
1991	54.5	956.8	220.7	322.5	154.5	150.8	109.0
1992	57.6	1073.5	241.1	359.9	169.1	180.2	123.2
1993	58.6	1122.8	245.2	378.3	184.9	185.3	129.1

Sources: *The Central Bank Annual Yearbooks*;
Plan and Budget Organization, *Performance of the First Five Year Plan*, 1994.

Table 2 provides details of consumption of refined products in Iran during the last 28 years. Noteworthy is the decrease in the share of kerosene, from over 20 per cent in the 1970s to about 15 per cent in the 1980s. Figure 3 shows that the rate of increase in consumption of all products

[7] Salehi-Isfahani (1992).

Consumption of the four main refined products
(1000 b/day)

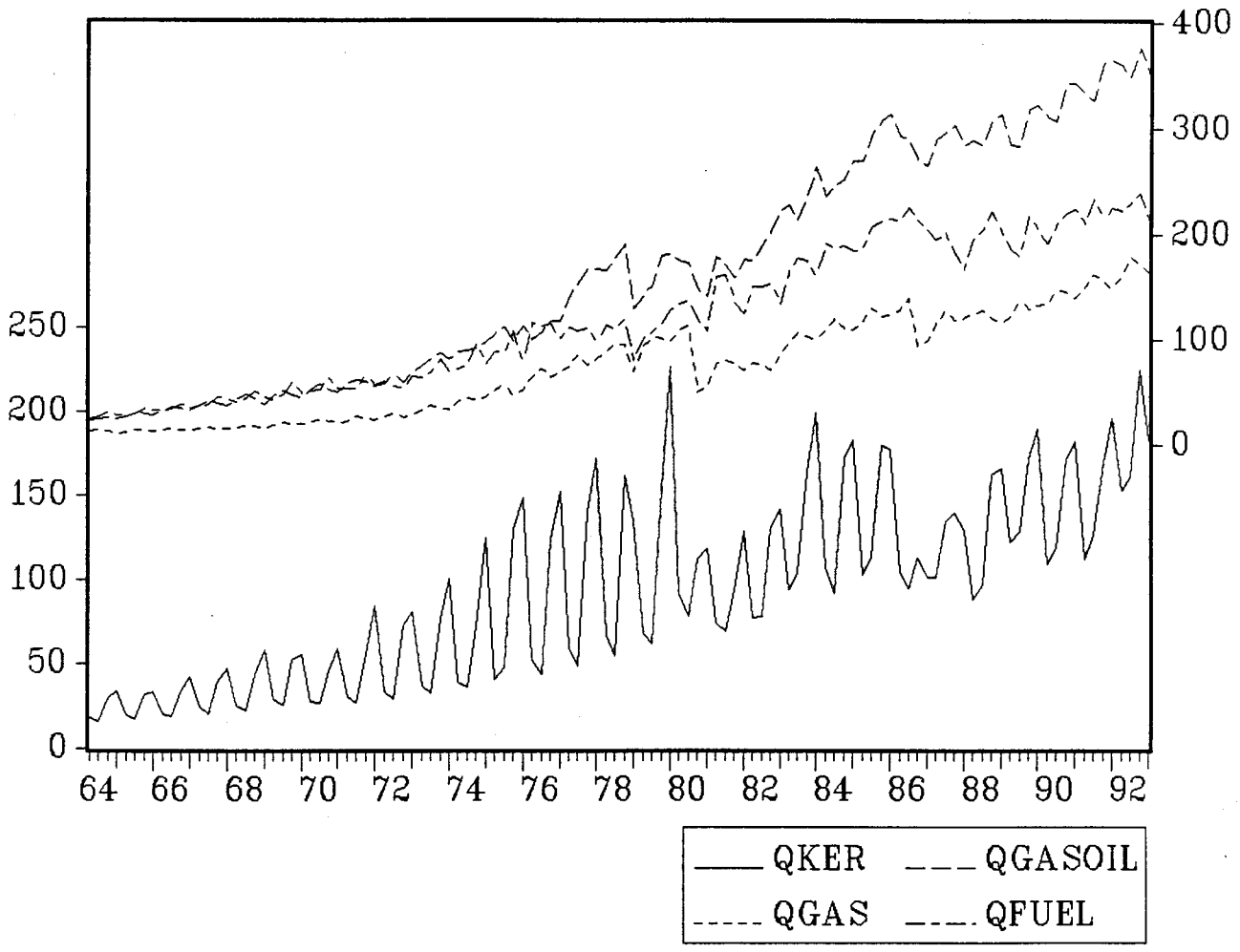

Figure 3

declined significantly in the 1980s, with kerosene and gasoline showing a larger decline than fuel oil and gasoil.

IV. Prices

Before March 1995, only gasoline prices had been adjusted upwards. As a result, differentials between products have widened since the revolution, reflecting, as Sterner (1989) has noted for other countries, the shift in the social basis of political power. Thus, in 1995, at 100 rials per litre the price of gasoline (which is nearly twenty times its price in 1979), was five times the price of gasoil and kerosene and ten times the price of fuel oil. Politically, the gasoline price has been the easiest to adjust. It was first increased by 200 per cent in 1980 and then along with other products by 66 per cent in 1987. In March 1995 all refined product prices were doubled.

It is difficult to compare these prices with those in the world market because of the multiplicity of the exchange rates. In 1995 there were at least three rates, the official rate of 1750 rials per dollar, the export price of 3000 and the black market price of about 3700. If we take the exchange rate of 3000 applied to exports as our measure of the opportunity cost of foreign exchange, after the doubling of prices in March 1995, the dollar prices of refined products ranged from about 2 cents per gallon for fuel oil to 9 cents per gallon for gasoline, all only a fraction of their respective border prices.

The major substitute for petroleum products in Iran is natural gas, which is increasingly used in electricity generation, household and commercial use, and to a lesser extent, in industrial use. As the world's second largest owner of gas reserves, Iran is in a position to substitute gas for a large part of its petroleum use. A major obstacle to doing so is the low price of petroleum products. Until 1987 competing oil products were cheaper than natural gas. For example, fuel oil was 2 rials per litre compared to 5 rials per cubic metre for natural gas, making fuel oil 60 per cent cheaper per BTU. Price adjustments since 1987 have made natural gas slightly more competitive. In 1994, at 5 rials per litre fuel oil was just equal in heat cost to natural gas, but, taking into account the cost of equipment change, it may not have been profitable to switch. Kerosene which was 60 per cent cheaper per BTU than natural gas in 1987 was in 1991 priced at the same rate. Still higher prices for petroleum products are necessary to increase substitution and take full advantage of the cheaper natural gas.

V. Efficient Pricing

Because of its huge social and economic impact, it is important that adjustments in consumer prices of petroleum products be based on firm economic reasoning. In general, the efficient domestic price of a traded product is its border price. But in the case of oil the border price may not be a good guide because of imperfections in the market for crude oil (Schramm 1985). For example, assuming production capacity is variable, if a country's exports are limited by quota it can optimally price discriminate between the domestic and export markets, charging the monopoly price in the international market and opportunity cost in its domestic market.[8] In the case of OPEC there are two complications. First, there is serious doubt as to the importance of quotas in determination of supply.[9] During the 1970s there were no quotas, and for most of the 1980s, they have been less than perfectly observed. Second, surprisingly for an export cartel, OPEC quotas are imposed on production rather than exports.[10] A strict application of quotas to production would mean that opportunity cost of oil sold domestically is its border price, which implies that price discrimination is not justified.

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[8] If capacity is fixed then the opportunity cost is simply the world price and there will be no price discrimination.

[9] See Crémer and Salehi-Isfahani (1991), Chapter 3.

[10] OPEC defines production for the purpose of setting quotas as net exports plus domestic consumption plus sale from overseas stocks.

But, production quotas are likely to change if several countries were to switch enough sales from their domestic to the world market to cause the world price to decline. It should be expected that in that case those countries would be under pressure to lower their exports by accepting lower quotas. Conversely, individual countries should be able to raise their quota if they can convince other cartel members that the extra output will not find its way to the world market (either as crude or refined product) but is purely for domestic consumption. In this case, quotas should be judged to be in effect on exports, in which case price discrimination makes economic sense.

If capacity rather than quota were the binding constraint on production the optimal price would be the border price. Fixed costs of capacity generation in the short run create the same effect as exogenously determined capacity, but in the long run, when these investments can be undertaken, capacity should be viewed as endogenous and adjusting to the desired production level. Thus in the long run lack of excess capacity does not necessarily imply that opportunity cost equals the border price. Ever since the imposition of quotas in 1982, Iran's production appears to have been determined by capacity rather than quota allocations, for Iran has consistently adjusted its quota to increased capacity.

Where the border price is not a good guide for domestic pricing, the question arises as to the true opportunity cost of oil. A barrel consumed today is not available tomorrow; this is likely to be more true for a single country than for the world as a whole. Opportunity cost in this case is very hard to determine because it is a forward-looking concept. Expected future prices and costs would then be important in deciding what price to charge for domestically consumed oil.

In Iran, wide distortions in the economy at the present time add to the complications in the determination of the optimal price. In general, in the presence of distortions, the international price is not necessarily the optimal price (Dixit and Newbery 1983, Newbery 1985). Even if we were to take the border price as the optimal price the distortions in the foreign exchange market prevent a simple conversion to the local currency. Border prices for producers are efficient as long as other prices - output and non-energy inputs - faced by producers are also efficient. In Iran these prices are in general highly distorted, in part because of the multiplicity of exchange rates and in part due to government price controls. Since these distortions are once again widespread, border prices cannot be used. Adjusting petroleum products prices therefore should be part of a more general price reform, including the unification of the multiple exchange rate system.

The logic of setting consumer prices is somewhat different than producer prices. Fuel used in transportation should be taxed (rather than subsidized as it is at present) to pay for the cost of using the roads. Prices of gasoline and gasoil used for transport should therefore be higher than their border prices. Like producer prices, consumer prices set artificially can induce inefficient consumption patterns, in the sense that welfare can be increased by substituting in consumption another good of equal cost for the subsidized good. An example would make this point clear. An Iranian driver who in 1995 could buy a litre of diesel fuel at 20 rials (or less than a cent at the exchange rate of 3000 rials per dollar), would obviously find it a great deal. But if she were given a choice between a litre of diesel and its value in the world market *in dollars*, she would most likely prefer (at the margin) to trade the fuel for its value in the world market (approximately 20 cents), as she could buy with it a more valuable item, such as food or medicine. Cheap fuel in that case would not be such a good deal.

VI. Econometric Estimation of Demand for Petroleum Products

In this section I present the results of estimation of demand equations for the four main petroleum products. My objective is to answer questions such as these: Have low prices distorted consumption significantly? Is the intensive nature of energy use in Iran the result of low prices? Is demand sensitive to price or is it more driven by income? If subsidies were to be removed completely would demand for refined products stabilize and thereby allow steady exports of 2.5 mb/d in the long run? Knowledge of price and income elasticities would help provide a better basis for demand projection in the future. My choice of estimating product demand rather than demand for use (eg. transportation) is forced by the availability and quality of data. Product consumption data are of

good quality and available consistently on a quarterly basis. Consumption data classified by use are not as reliable and are only available on an annual basis and for a limited number of years. Fortunately, in Iran there is a close correlation between use and type of product. Kerosene is used mainly for household heating and cooking, fuel oil for industrial purposes, and 90 per cent of gasoil is for use in commercial transportation and the rest for heating. Only gasoline is more evenly divided in its use for commercial and private transportation, but there is no data on the exact proportions.

Demand in Iran, as perhaps in other oil-exporting countries, should be less price elastic because of heavy reliance on oil. Although the findings of this section give credence to this expectation, the overall level of estimated elasticities are quite consistent with those found elsewhere in developing countries. Dahl (1991) summarizes these findings for petroleum product demand in less developed countries as - 0.3 for price and unity for income elasticity in the long run.

VII. Modelling Approach

The modelling approach is guided by the objective to study the role of price and income in energy demand. Several points should be raised with respect to the choice of the estimation model.

1. Constant elasticity. I use the popular log-linear equation which assumes that price and income elasticities are constant. This is a bit unsettling when we note that in our sample the range of price and income changes are rather large, but the convenience of interpretation and the advantage of non-linear estimation make this worthwhile.[11]

2. Simultaneity bias. In general demand and supply should be estimated jointly, but in our case product prices are exogenous and their supply adjusts (mainly through exports and imports) to clear the market. Nominal product prices are fixed by the government and overall inflation is not affected by demand and supply for petroleum products. Therefore the real prices of products are exogenous and the observed quantity-price data trace the demand curve. The only exception is for kerosene for the period in which the marginal price was the black market price (see below).

3. Cross price effects. Testing for cross price effects is hampered by the strong collinearity between the real price series (see Figure 2). To prevent multicollinearity from reducing the precision of the own price and income effects, I tested for the most likely substitutes. For example, in demand for gasoline I included only the gasoil price, since there is no basis for accounting for variation in the price of kerosene or fuel oil, which are, in any case, mostly picked up by the other two prices.

4. Population. The choice to include population as a determinant of demand is based on whether one believes that the number of people influences demand over and above aggregate income. In all cases I tested for this by including population as an explanatory variable; only in the case of kerosene was there any indication that population influenced consumption.

For estimation I employ dynamic reduced form equations. I tested both static and dynamic forms and the data strongly favoured the latter. The static version assumes that demand adjusts quickly to price and income changes, so that we can write:[12]

$$Q_t = a + bP_t + cY_t + dP_t^{sub}, \qquad (1)$$

where Q_t is consumption, P_t is price and P_t^{sub} is the price of a substitute. In the dynamic version, desired demand Q_t^* is determined by price and income, and actual consumption Q_t adjusts to the

[11] The linear demand functions I estimated do not differ much from log linear models in terms of forecasts they provide. For a discussion of the double-log formulation in modelling energy demand see G. D. Nan and D. A. Murry (1992).

[12] All variables are in logarithms. For ease of notation I drop the prefix ln.

desired level only partially in each period (i.e., each quarter). This version makes more a priori sense because refined products are used in conjunction with fixed capital. Thus, assuming that actual demand responds to desired demand with a lag, we can write,

$$Q_t + Q_{t-1} + \lambda(Q_t^* - Q_{t-1}), \tag{2}$$

where λ is the speed of adjustment. The estimated demand function is then:

$$Q_t = a\lambda + b\lambda P_t + c\lambda Y_t + d\lambda P_t^{sub} + (1 - \lambda)Q_{t-1} \tag{3}$$

Data. Income is measured by non-oil GDP at constant prices. Non-oil GDP is a better measure of the level of economic activity in the country. Sale of petroleum products for the earlier years are taken from the Central Bank of Iran, *Quarterly Report*, various issues; for the later years the data was supplied by the Ministry of Oil. The quarterly price of kerosene in the black market is supplied by the Central Bank, other prices by the Ministry of Oil. Product prices were deflated by the Consumer Price Index published by the Central Bank.

Prices and product consumption data are available on a quarterly basis, but income and population are only available annually. To take advantage of the information contained in the quarterly price and output series, I have converted the annual series to quarterly using the annual growth rate as a trend for the year. Kerosene consumption exhibits strong seasonal variation due to the demand for heating (see Figure 3). Gasoline also has some seasonal variation as driving drops during fall and winter, but gasoil and fuel oil, whose demand is more industrial than the other two do not have much seasonal variation.

VIII. Empirical Results

The above functional forms were applied systematically to all products. I discuss the results for each product separately.

Fuel oil. The estimation of demand for this product is the most straightforward. The consumption of fuel oil was not affected by rationing, as in most years there was a surplus of domestically refined fuel oil. Table 3 presents the results for two regressions of per capita fuel oil consumption. First note that the price of gasoil which is included in the regression in column 2 has the right sign but is not significant. Other product prices (kerosene and gasoline) which in theory should have even less of an effect on demand for fuel oil also performed very poorly. Evidently, there is no noticeable cross price substitution effect on demand for fuel. Nor are other coefficients affected by including the price of gasoil. We can therefore focus attention on the first column that reports the regression results without any cross price effects. All coefficients are significant except for the summer and spring dummy variables. The estimated short-run price and income elasticities are -0.12 and 0.42, and long-run elasticities are -0.25 and 0.86, respectively.[13] Seasonalities are as expected and indicate a 10 per cent drop in consumption of fuel oil in the winter quarter compared to the average for the year.

[13] Long-run elasticities are calculated by dividing the short-run elasticity by 1 - λ, where λ is the estimated coefficient for the lagged quantity.

Table 3: Demand for Fuel Oil
Dependent Variable: Total Consumption of Fuel Oil

Variable	(1)	(2)
Constant	-1.32 (3.98)	-1.28 (3.84)
Price elasticity	-0.12 (4.14)	-0.08 (1.44)
Income elasticity	0.42 (5.27)	0.42 (5.27)
Lagged consumption	0.52 (6.76)	0.51 (6.52)
Summer	-0.01 (0.36)	-0.01 (0.33)
Fall	0.05 (1.77)	0.05 (1.79)
Winter	-0.10 (3.68)	-0.10 (3.62)
Gasoil price	---	-0.05 (0.77)
Long-run price elasticity Long-run income elasticity	-0.25 0.86	-0.16 0.85
R^2 Durbin-Watson	0.98 2.22	0.98 2.20

Gasoil. As for fuel oil, demand for gasoil was little affected by rationing. This is evident from examination of the quarterly data (Figure 3) and the lack of any black market for gasoil. Therefore, equation (3) can be estimated without modification. Gasoline and kerosene are likely substitutes for gasoil, the first in transportation and the second in heating. Only 10 per cent of all gasoil is used in heating and the bulk is in transportation, so the gasoline price should play a more important role in demand for gasoil. Furthermore, because the price of gasoil declined faster than gasoline, one would expect switching to gasoil (diesel) powered cars and trucks to have raised demand for gasoil. But such substitution requires change in the mix of vehicles, and supply of new vehicles after the revolution was restricted to production from an unchanging domestic capital stock.[14]

Therefore, possibilities for substitution between gasoil and gasoline were quite limited. The coefficient for the price of kerosene is of the right sign and insignificant, but, surprisingly, that for gasoline is of the wrong sign and is significant. There is no easy explanation for the apparent-complementarity between gasoil and gasoline. As far as forecasting is concerned, it is comforting to note that the elasticity of the gasoline price is quite small (-0.07) and that the other elasticities are quite stable when we introduce the cross price effects. There is little seasonality evident in the consumption of gasoil.

Short-run price and income elasticities are remarkably close to fuel oil; only in the long run is gasoil more price and income elastic than fuel oil.

[14] In 1987 45 per cent of all commercial vehicles (e.g., vans, lorries, etc.) were built before the revolution (*Statistical Yearbook Of Iran*, 1989, p. 318).

Table 4: Demand for Gasoil
Dependent Variable: Total Consumption of Gasoil

Variable	(1)	(2)
Constant	-1.57 (4.17)	-1.84 (4.67)
Price elasticity	-0.13 (3.45)	-0.13 (3.50)
Income elasticity	0.39 (4.77)	0.45 (5.26)
Lagged consumption	0.64 (9.22)	0.58 (7.98)
Summer	0.01 (0.46)	0.01 (0.63)
Fall	-0.02 (0.69)	-0.01 (0.50)
Winter	-0.04 (1.79)	-0.04 (1.55)
Gasoline price	---	-0.07 (2.33)
Kerosene price	---	0.003 (0.19)
Long-run price elasticity Long-run income elasticity	-0.35 (1.10)	-0.32 1.08
R^2 Durbin-Watson	0.99 2.09	0.99 2.07

Gasoline. The price of gasoline between 1986 and 1990 was two-tiered, a coupon price of 30 rials per litre and a 'free' market price of 60 (at which an unlimited amount could be bought, both sold at all (government-owned) gas stations. To take account of this duality in price (a form of rationing) I averaged the two prices using actual sales as weights. Gasoline rationing was removed and a single price was set in February 1991.

Gasoil is the principal substitute for gasoline, but its price does not appear to influence demand for gasoline. Demand for gasoline exhibits strong seasonality, dropping during fall and winter quarters by as much as 17 per cent. Short- and long-run price elasticities are close to those estimated for fuel oil and gasoil, but income elasticities are higher. The long-run income elasticity of 1.51 confirms the notion of gasoline as a luxury good whose price should be set, on distributional grounds, higher than that of other products.

Table 5: Demand for Gasoline
Dependent Variable: Total Consumption of Gasoline

Variable	(1)	(2)
Constant	-1.67 (5.21)	-2.82 (5.38)
Price elasticity	-0.12 (3.81)	-0.12 (3.76
Income elasticity	0.53 (5.51)	0.56 (5.67)
Lagged Consumption	0.65 (10.99)	0.60 (8.42)
Summer	0.02 (0.92)	-0.03 (1.16)
Fall	-0.17 (6.17)	-0.16 (5.57)
Winter	-0.09 (3.55)	-0.08 (3.44)
Gasoil price	---	-0.04 (1.28)
Long-run price elasticity Long-run income elasticity	-0.35 1.51	-0.32 1.40
R^2 Durbin-Watson	0.99 2.23	0.99 2.17

Kerosene. As noted earlier, unlike other refined products, kerosene was severely rationed during the 1980s giving rise to a black market. A significant amount of kerosene found its way into the black market where in certain months prices were as much as 20 times greater than the official price. Rationing was officially removed in 1992. We are forced to take this particular market structure into account. For a number of years consumers purchased at two different prices: the official, coupon price and the black market price. Fortunately, we have data for the black market price for kerosene, as the Central Bank collected this information for its Consumer Price Index. But, due to its illegal nature, the actual quantities sold through the free market were not recorded. The Central Bank has used an arbitrary share of 20 per cent for the free market in its CPI calculations. Many officials believe this to be an underestimate.

Despite the lack of adequate data, it is unwise to ignore the black market altogether. Elasticities obtained from estimation with the official price in the demand equation are about twice as high as those with some form of accounting for the black market. Clearly, without knowing the quantities sold in the black market it is not possible to fully model the black market. I try two simple ways to utilize the information contained in black market prices. First, I replace the official price with an average of the official and the black market price. Columns 1-3 of Table 6 present the results according to this method. In a slightly more ambitious attempt I take into account the income effect as well as the price effect of the rationing (columns 4-6).

Table 6: Demand for Kerosene
Dependent Variable: Total Consumption of Kerosene

	No rationing			*With rationing*		
Variable	(1)	(2)	(3)	(4)	(5)	(6)
Constant	-3.07 (6.02)	-3.36 (6.13)	-3.55 (3.39)	-3.33 (6.64	-3.63 (7.18	-3.75 (4.29)
Price elasticity	-0.10 (2.92)	-0.08 (1.98)	-0.09 (2.21)	-0.05 (2.08)	-0.05 (1.98)	-0.06 (2.20)
Income elasticity	0.75 (6.36)	0.70 (5.54)	0.69 (5.59)	0.78 (6.50)	0.68 (5.47)	0.67 (5.40)
Lagged consumption	0.25 (2.59)	0.22 (2.22)	0.21 (2.12)	0.30 (3.12)	0.22 (2.21)	0.21 (2.09)
Summer	0.12 (1.56)	0.09 (1.22)	0.09 (1.16)	0.15 (1.94)	0.09 (1.20)	0.09 (1.14)
Fall	0.72 (9.20)	0.70 (8.65)	0.69 (8.53)	0.76 (9.59)	0.70 (8.60)	0.69 (8.45)
Winter	0.71 (15.10)	0.70 (14.87)	0.70 (14.70)	0.71 (14.96)	0.70 (14.82)	0.69 (14.64)
Population	---	0.25 (1.41)	0.29 (0.86)	---	0.39 (2.45)	0.40 (1.24)
Natural gas	---	---	-0.01 (1.11)	---	---	-0.01 (1.11)
Gasoil price	---	---	-0.05 (0.40)	---	---	-0.07 (0.55)
Long-run price elasticity Long-run income elasticity	-0.14 1.00	-0.09 0.89	-0.13 0.90	-0.14 1.00	-0.08 0.90	-0.13 0.90
R^2 Durbin-Watson	0.94 1.77	0.94 1.77	0.94 1.77	0.94 1.78	0.94 1.78	0.94 1.78

Because kerosene is used mainly for heating and cooking it may be influenced by population as well as total income. Columns 2 and 5 report on the regression including population. In one case the coefficient is not significant but on the whole it appears that population influences demand for kerosene. Interestingly, the estimated price and income elasticities are not affected much by including population. Another complication is the substitution of natural gas for kerosene which started in 1980. Since natural gas was also rationed, albeit for a different reason - only those connected to the network could use it - its price relative to kerosene was much less important than whether or not it was available. Therefore, rather than include the price of natural gas, I include its quantity in the regression equation. In columns 3 and 6 the coefficient of natural gas is of the right sign, but it is very small and not significant, indicating that substitution with natural gas has had a negligible effect on demand for kerosene. Substitutability with gasoil also finds little support in these regressions, as the coefficient is of the wrong sign. The strong seasonal variation observed in the data is confirmed by the regressions. Fall and winter demand is 70 per cent higher than spring.

The most notable result for kerosene is the much smaller price elasticity. This indicates that the distributional losses due to the subsidy are much smaller than in the case of other refined products. Given the large negative social impact from increasing the price of kerosene, one might argue that the efficiency aspects are outweighed by the considerations of equality.[15] However, as pointed out earlier, this does not mean that the government should continue to subsidize the consumption of all income classes by keeping the price of kerosene low. The large estimated income elasticity of nearly one implies that consumption of kerosene increases in proportion to income; that is, there are plenty of higher income families who also consume kerosene. The general price subsidy should therefore be substituted by a specific income or consumption subsidy targeted at the poor.

I now describe the simple model that takes the income effect from rationing into account. The black market in kerosene appears to have operated as follows. The government was the sole supplier of kerosene through official distributors who had to account for their allocation by returning to the government the coupons they collected from the households. There is no evidence of secondary sales by consumers, so the free market was fed directly by the distributors themselves who bought the necessary coupons from intermediaries for accounting to the government. Presumably, the supply of coupons came from poorer households, especially those in the rural areas, whose demand (given the black market price) fell short of their ration. The intermediaries, usually found in the main crossings in towns and cities, bought the coupons and sold them to the distributors. This scenario is supported by anecdotal evidence from individual households who frequently complained that distributors kept very short hours and preferred to deliver kerosene, for a premium, to the door rather than sell it at the shop.

Given the confines of the aggregate demand function, we can approximate the working of this market by assuming that the demand side consists of a single (average) buyer who obtains part of her kerosene at the official (coupon) price and the rest at the free market price. It is easy to show that this is equivalent to the purchases of a consumer who is given a subsidy equal to the value of the coupon but who has to buy all her kerosene at the free market price. To see this consider the budget constraint of a consumer who buys kerosene in the official and black markets at prices $\overline{P}_K$ and P_K, respectively. With some re-arranging it can be written as:

$$Y + (P_K - \overline{P}_K)\overline{X}_K = P_O X_O + P_K X_K \qquad (4)$$

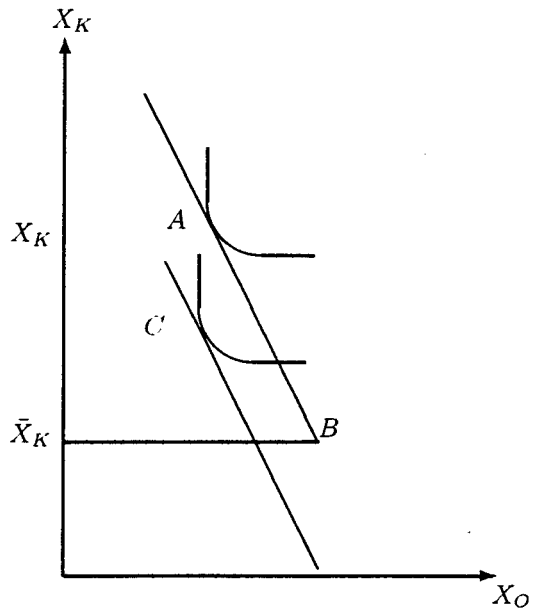
This is the budget constraint of a consumer with income $Y + (P_K - \overline{P}_K)\overline{X}_K$ who buys X_K of kerosene and X_O of other goods at market prices. This equivalence is depicted graphically in Figure 4 assuming $\overline{P} = 0$.

A consumer without ration coupons buying only at the black market would be at C; with coupons her budget constraint shifts up so that she can afford B and choose A. The slope of the budget line is $\frac{P_K}{P_O}$.

To implement this model, I calculate the value of the subsidy assuming a fraction of one-third for the size of the free market. The amount of the subsidy is in fact very small, less than 1 per cent of the total consumption expenditures at its highest level. As a result, the influence of the arbitrary fraction is very small. The results are presented in Table 6, columns 4-6. The estimated short run price elasticity is even smaller than those in columns 1-3, and indicates a very inelastic demand for kerosene.

Some caveats for the kerosene results should be noted. Unlike the markets for the other petroleum products, because of the importance of the black market, price in the kerosene market during the years1986-1992 was not really exogenous. This indicates a possible source of bias due to simultaneity. Since the price switches from being exogenous to being endogenous during the sample period, there is no obvious way to correct for the bias without running separate regressions. Unfortunately, the rationed sample is too small to yield precise estimates independently. With more

[15] For a discussion of efficiency vs. equity in energy pricing in developing countries, see Julius (1986).



Consumer behavior under rationing with a black market

Figure 4

Forecast of total refined product demand, 1994–2010 (1000 b/day)
Constant nominal prices

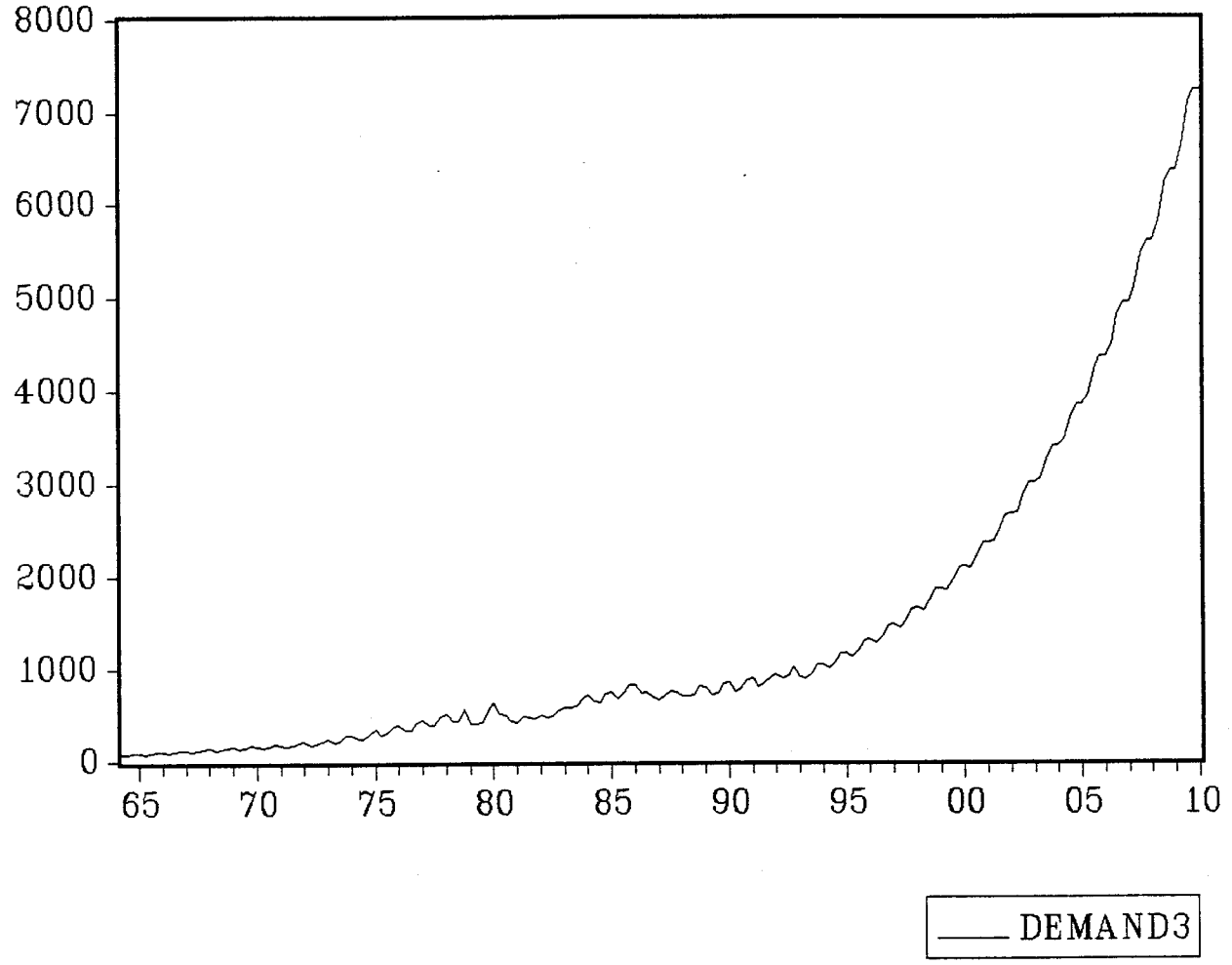


Figure 5

Forecast of total refined product demand, 1994–2010 (1000 b/day)
Constant real (1995) prices

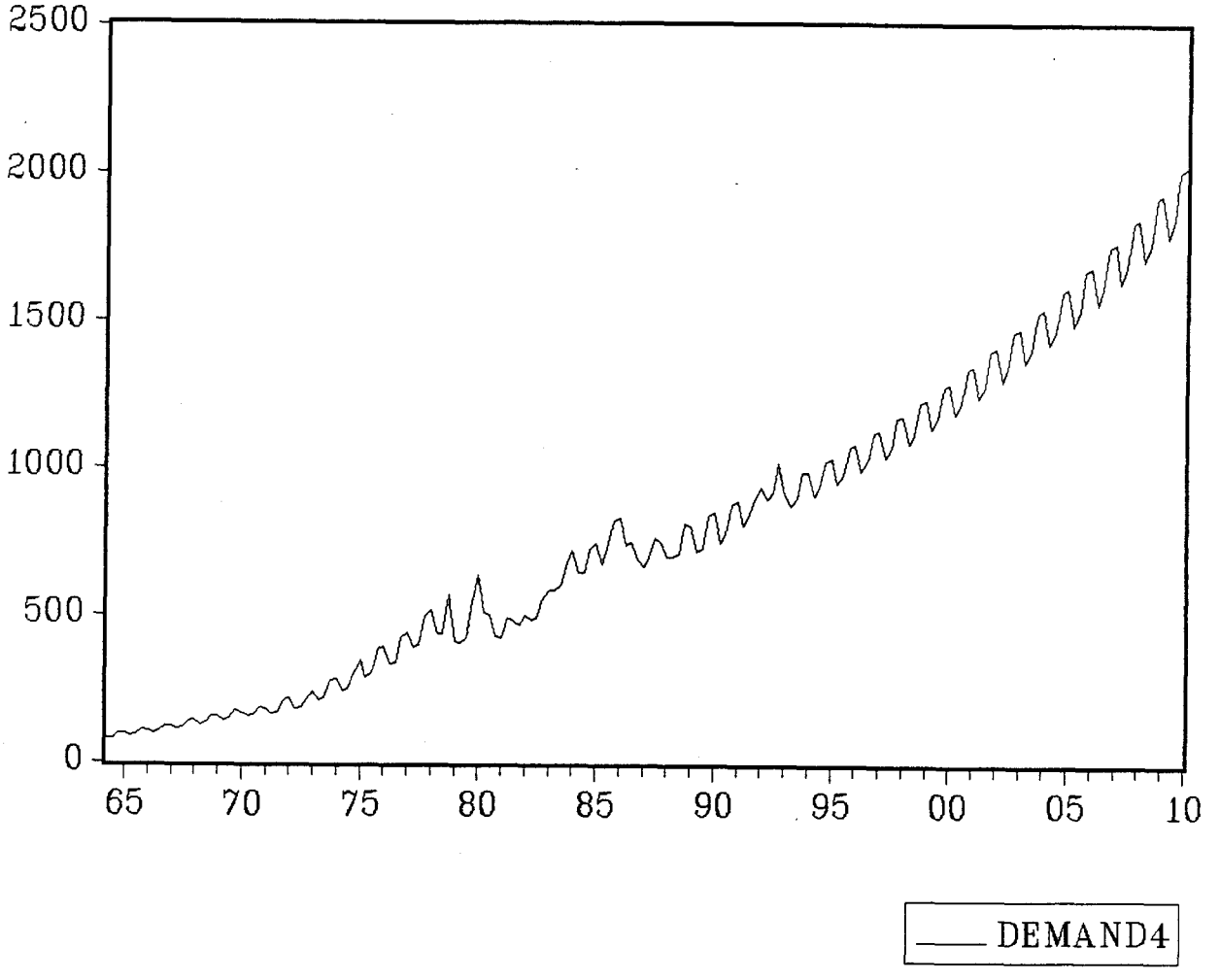


Figure 6

Forecast of total refined product demand, 1994–2010 (1000b/day)

Border prices reached by the year 2000

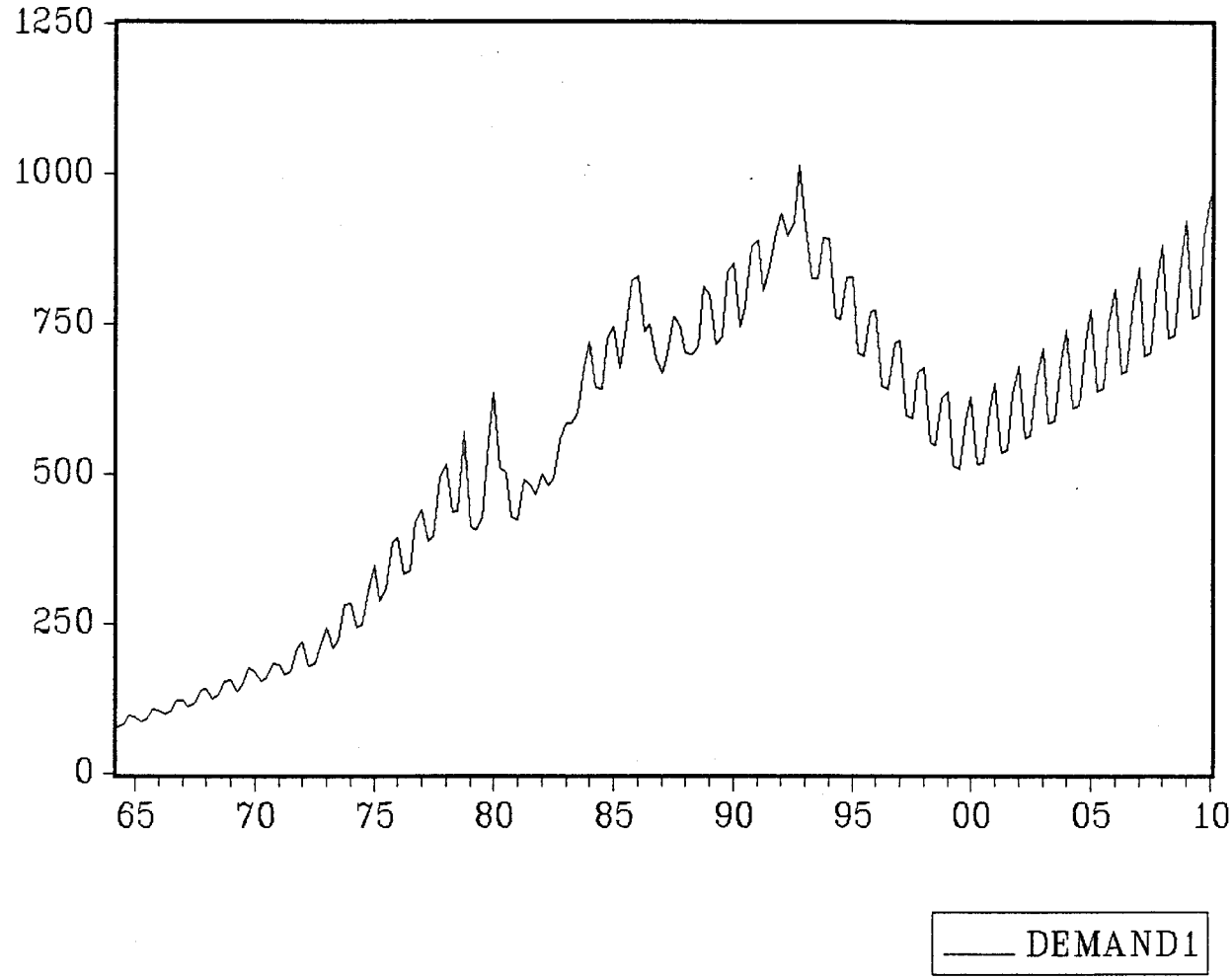


Figure 7

Forecast of total refined product demand, 1994–2010 (1000 b/day)
Border prices reached by the year 2010

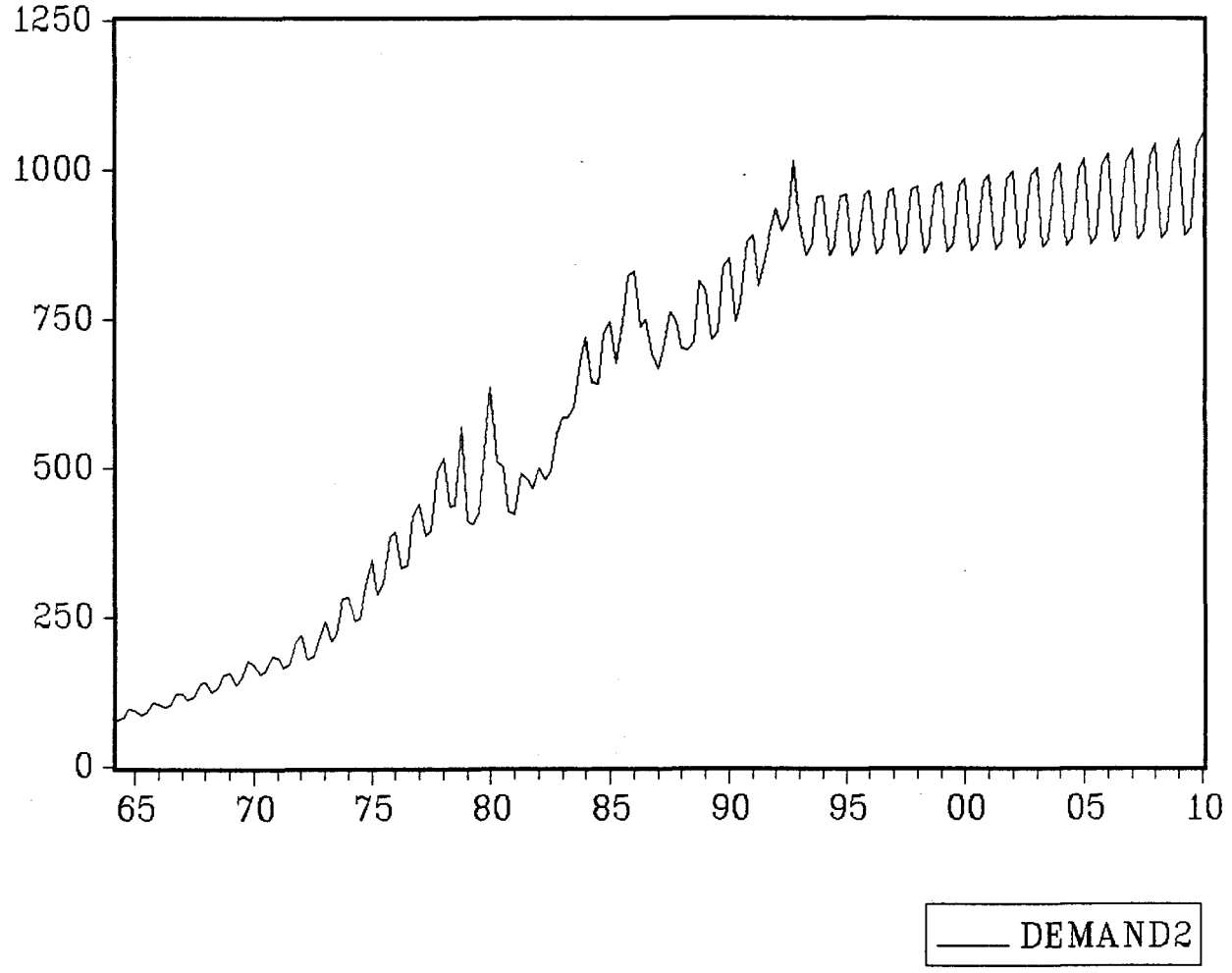


Figure 8

detailed data on the kerosene market one can hope to overcome this problem. Also, the simple rationing model employed above assumes identical individuals which is inconsistent with the existence of the black market. Unfortunately, a more detailed model with both buyers and sellers in the black market cannot be implemented at this stage because no data on quantities traded in the black market are available.

IX. Forecasts

To understand the implications of the estimates made for the future of the oil industry in Iran, I forecast total refined product demand using the individual product demand functions. Because the estimates of the cross-price elasticities were not generally significant, to increase the precision of the forecasts, I used the equations without other prices. It should be recalled that price and income elasticities were basically the same in different specifications. To focus on the role of prices, I allow for only a modest growth in the economy to the year 2010. Non-oil GDP is assumed to grow at 4 per cent per year. Inflation is assumed at 30 per cent, which is the average for the last five years. World prices of refined products are assumed to be unchanging. These forecasts ignore the effect of energy prices on inflation and output.

Even with such a limited effect from income, the policy of doing nothing to adjust prices above their current level, i.e. politically the most convenient option, would result in an unsustainable demand (Figure 5). Domestic demand reaches total capacity - i.e. no exports - in just 10 years. By the year 2010 demand is nearly twice the existing capacity. In this scenario subsidies per unit of consumption increase. If prices are increased at the rate of inflation, 30 per cent per year, so that real prices are frozen at their current levels - that is, only a fraction of their border prices--so that subsidies only increase in proportion to demand, consumption would double in fifteen years, exceeding 2 mb/d, which is about half the existing capacity (Figure 6).

Subsidies can be removed completely by raising prices to their world levels, but the speed of adjustment makes a difference. If prices are increased to their world levels (the stated objective of the government) demand would stabilize at its current level. This can be done by either a shock treatment that raised prices to the world level in five years or a more moderate pace that achieved the same in fifteen years. In the former case real prices have to increase by about 30 per cent per year for five years, which, given my assumptions about inflation, implies nominal increases of 60 per cent. After the year 2000 prices have to only increase at the rate of inflation. Demand actually falls to the year 2000, but starts growing again, barely reaching its present level by the year 2010 (Figure 7). Decline in demand would mean serious economic disruptions. In view of this a less sudden shock is worth considering. If prices are adjusted more slowly to achieve parity with the world price in fifteen years, consumption would still be able to grow, but at less than 1 per cent per year such that by the year 2010 demand in the two cases are only apart by less than 100 tb/d (Figure 8). Therefore, from this point of view a more gradual policy seems more desirable.

X. Conclusions

After a slowdown during the 1980s that may be best attributed to decline in the level of economic activity and rationing, Iran's domestic consumption of refined products has resumed its rapid growth in the 1990s and promises to do so in the future. Plans for expansion in oil production capacity that aim to raise the foreign exchange earnings from oil may be frustrated if domestic consumption is not restrained. If prices are to be adjusted at all, it is best to do so early in the recovery process. Because adjustment in demand requires some capital expenditure, and the private sector is likely to be modernizing its capital stock in the near future, the lead time in the price signal is very important. If there is going to be a renewal of investment in Iran in the 1990s, it is better to have the adjustment to higher fuel efficiency now than after the boom has peaked.

The estimated income elasticities presented here indicate that, all else held constant, consumption of petroleum products will increase at the same rate as income. Thus rapid growth experienced during the First Plan is probably responsible for the post-war increase in oil consumption. However, even during slowdowns consumption can grow because prices keep falling

in real terms. The estimated price elasticities reveal a potential for adjustment if prices are increased, which would help keep demand down while the economy grows. Forecasts based on the estimated models here indicate that consumption can be stabilized at current levels by raising prices to their world levels in fifteen years. This policy would therefore have two desirable properties: allow expansion of oil production capacity to generate increased oil exports and more foreign exchange, as well as move Iran toward economic efficiency. The consequent distributional aspects are significant but should be handled by a comprehensive programme of social security.

The analysis of this paper is generalizable to many other oil-exporting countries. Government monopoly of domestic supply of petroleum products, low cost of extraction of crude oil, and the popular perception that resource abundance must mean cheap fuel, are conditions shared by many oil-exporting countries in the Middle East and elsewhere. Having insulated domestic consumption from the price increases of the past twenty years, many governments of oil exporting countries now consider it in serious competition with exports. The combination of large subsidies and non-negligible price elasticities found in the case of Iran suggests that domestic pricing policy has an important effect on the oil-exporting countries' ability to perform in the international oil market in the long run. If domestic prices are not adjusted oil exports will come under pressure, not so much from OPEC quotas as from soaring domestic consumption. Given the price responsiveness apparent from this and other studies, the removal of petroleum subsidies will do more than improve the internal deficit, it will also help with the external balance.

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