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The Effects of Energy Subsidy Reform on Fuel Demand in Iran

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Abstract

To prevent further increases in energy consumption, the government of Iran commenced energy subsidy reform in 2010. This paper investigates the fuel conservation effects of the reform in Iran using a homothetic translog cost function that provides estimates of the own- and cross-price elasticities of fuel demands. The percentage reduction in fuel demands is estimated using the likely effect of the reform on fuel prices. The results reveal that the reform may not be as successful as assumed. Under optimistic assumptions, the reform may reduce energy consumption marginally, and under pessimistic assumptions, it may increase energy consumption because of inelastic fuel demands and substantial substitution between fuels.

Keywords: *Energy subsidy reform, Fuel demand, Iran, Translog cost function*

JEL Classifications: *C32, Q38, Q43*

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1. Introduction

Iran has been one of the main oil exporting countries, but has encountered the problem of large increases in energy consumption and CO2 emissions. The growth in energy consumption has been so strong that Iran would become a net importer of refined oil products, if the current trend continues. Iran consumed 338 MBOE[1] of energy carriers in 1990, but this increased to more than 1100 MBOE in 2013. On a per capita basis, final energy consumption was 6.21 BOE in 1990, increasing to 14.33 BOE in 2013. The trend is similar for environmental emissions. In total, 605 MT of CO2 were emitted in 2013, compared with only 211 MT in 1990. Since the 1980s, the main contributors to energy consumption and CO2 emissions have been the residential, public and commercial sectors and the transportation sector (MoE, 2014).

The growth in energy consumption is a result of various structural and economic changes. Since 1990, annual gross domestic product (GDP) growth in Iran has experienced an average of 3.5% per year (Appendix 1). Oil revenues have accounted for a significant share of total GDP, meaning that fluctuations in global oil prices are transmitted to the domestic economy. This explains why GDP and the oil revenues are pro-cyclical. Thanks to abundant oil and gas reserves, income per capita has increased considerably in recent decades. While the average income in Iran was more than 10,000 USD (PPP) at the beginning of the 1990s, it almost reached 16,000 USD (PPP) in 2013 (World Bank, 2014). As energy products are normal goods [e.g. (Gillingham et. al., 2014)], the increase in real income can explain the increase in energy consumption in Iran.

The energy and CO2 intensities reveal other facts. Appendix 1 shows that whereas 0.59 BOE of energy carriers were consumed to produce 1000 USD of value additions (PPP) in 1990, energy intensity increased to 0.89 BOE/1000 USD in 2013, indicating 50% growth in more than two decades. Furthermore, CO2 emission intensity increased from 0.37 tons/1000 USD in 1990 to 0.49 tons/1000 USD in 2013.

The energy pricing system is the other determinant of ever-increasing energy consumption in Iran. Domestic energy prices have historically been set administratively in Iran at significantly lower levels than international or regional prices. Unsurprisingly, the government has filled the energy price gaps by paying enormous implicit subsidies. IMF (2013) reported that total

1. Million barrels oil equivalent.

energy subsidies exceeded 170 billion USD (PPP) in Iran during 2011. In other words, each Iranian received an annual energy subsidy of 2,216 USD (PPP), equal to 12.64% of GDP.

To rationalize the energy consumption, the Parliament of Iran approved the Reform Act on January 5, 2010. The Reform Act included the replacement of product subsidies with targeted transfers to the population, with some assistance to Iranian companies and the government. The Reform Act stipulated that households would receive at least 50% of the increase in revenues derived from the reform. Initially, the payment of benefits was to be in cash, while in a second phase, some of the additional revenues would support higher social benefits and public goods. Thirty percent of the additional revenues were to be used to assist Iranian companies to restructure and adjust to the new, dramatically higher, energy costs. The remaining 20% of additional revenues went to the government to cover the government's own higher energy bill. On December 19, 2010, Iran increased domestic energy and agricultural prices by up to twentyfold, making it the first major oil-exporting country to reduce substantially its system of implicit energy subsidies. In the next phase, prices would increase progressively until all subsidies were removed (Guillaume et al., 2011).

This paper is an attempt to investigate the fuel-conservation effects of energy subsidy reform in Iran. To study the conservation effects, a translog cost function is estimated and the own-and cross-price elasticities of fuel demands are derived. Using assumptions about the effect of the reforms on fuel prices, the reduction in fuel demands is estimated. The results of this study show that because of the inelasticity of fuel demands to their own prices and strong inter-fuel substitution, the reform cannot achieve the desired conservation targets. The paper is organized into six sections. In Section 2, the relevant past studies are reviewed. In Section 3 and 4, the translog cost function will be presented and the estimation results and the derived elasticities are described. Section 5 measures the energy conservation effects of the reform. The last section concludes and provides some policy implications.

2. Reviewing the Past Studies

Using translog cost or production function models, different studies have been carried out to estimate the elasticity of energy demand (as a factor of production) or the elasticities of different fuels (as constituents of the energy market) in developed and developing countries. The objective of these studies was to understand the sensitivity of consumers to fuel prices at sectoral, national, and international levels. For instance, some of the studies carried out at the sectoral level are Bölük and Koç (2010); for Turkey, Welsch and Ochsen (2005); for West Germany, Al-Mutairi and Burney (2002); for Kuwait, Christopoulos and Tsionas (2002); for Greece, Berndt and Wood (1975), Humphrey and Moroney (1975), Lakshmanan et al. (1984), Debertin et al. (1990), Stratopoulos et al. (2000), and Urga and Walters (2003) for the United States. The national level studies are Vega-Cervera and Medina (2000) for Portugal and Spain; Ma et al. (2009) for China; Cho et al. (2004) for South Korea; Perkins (1994) for Japan; and Magnus (1979) for the Netherlands. Some of the studies carried out at the regional or international level are Pindyck (1979), Renou-Maissant (1999), Söderholm (2001), and Roy et al. (2006).

Different studies have attempted to identify the determinants of the higher energy and CO2 intensities in Iran. Using an index decomposition analysis (IDA), Sharifi et al. (2008) showed that structural changes have had little effect in reducing the energy intensity of the manufacturing industries in Iran. Behboudi et al. (2010) attempted to identify the key factors affecting energy intensity in Iran by applying an IDA over the period 1968–2006. Their results indicated that increasing energy intensity was the result of a reduction of productivity and changes in the structure of economic activity. In addition, they found that energy prices play a critical role in determining energy intensity in Iran. The results of the study of Fotros and Barati (2011) indicated that the structure of economic activity has had the largest positive effect on CO2 emissions, with the exception of the industrial and transportation sectors. For these two sectors, structural changes have been the main driver of CO2 emissions. Sadeghi and Sojoodi (2011) studied the determinants of energy intensity in Iran manufacturing firms and found that a firm's size, ownership type, capital intensity and the wage level have significant impacts on energy intensity.

Some domestic studies have attempted to identify the effects of energy subsidy reform on economic variables. Using a CGE model, Shahmoradi et al. (2011) found that in short run the welfare and production decline, but imports and exports increase. Comparing with those studies with no redistribution consideration, they found that the cash payment policy compensates the welfare and productivity reduction to some extent. Following a computable general equilibrium approach, Manzoor and Haqiqi (2012) estimated that phasing out fossil fuel subsidies by 2020, would cut the expected growth in carbon dioxide emissions by 2 giga tons. Hoseininasab and Hazeri Niri (2012) found that reforming energy carrier's subsidies without income redistribution will result in a significant fall in total production and employment and will lead to higher inflation. On the other hand, supportive government policies will compensate increased production costs and will decline the percent of unemployment and reduction in total production. Abounoori et al. (2014)'s findings evidenced a deviation in production, labor supply, and inflation from their steady state due to the reform. Karimi et al. (2014) showed that according to a pessimistic scenario the increase in the exchange rate and consequently the price of imported gasoline price would decrease 60% of consumer welfare that amounted to 59 thousand Rails per household.

Several studies have estimated the inflationary effects of the energy subsidy reform in Iran. For instance, using a social Accounting Matrix Price Model, Perme (2005) concluded that removing the subsidies on refined petroleum products, natural gas, and electricity would increase their respective average national price indices by 19.52%, 11.07%, and 4.83%, respectively. Moreover, if the removal of all energy subsidies took place simultaneously, the price index would increase by 35.4%. Khiabani (2008) employed a standard CGE model and found that if domestic fuel prices increased to their international level, the inflation rate would increase by 35%. Shahmoradi et al. (2010) found that increasing inland fuel prices to their international level would increase consumer and producer price indices by 108% and 118%, respectively, while prices for freight and passenger rail transportation would experience an extraordinary increase of 263% in service prices. Heydari and Perme (2010) provided evidence that removing fuel and bread subsidies would potentially increase the related expenditures by urban and rural households by at least 33% and 40%, respectively. Applying a CGE model and using a micro-consistent matrix, Manzoor et al. (2010) examined the effects of implicit and explicit energy subsidy phaseout in Iran. They concluded that the policy would increase the inflation rate by between 57.9% and 69.07%. Finally, using an updated input–output price model, Hosseini and Kaneko (2012) found that the first phase of reform would increase consumption prices by 18.86% nationwide. They showed that the inflationary impact of overall subsidy removal is about 54.10%. In this study, we use the estimated CPIs in the authors' previous study (Hosseini and Kaneko, 2012) to calculate the real prices after the reform.

3. A Translog Cost Model

To measure the own- and cross-price elasticities of fuels, we employ the two-stage estimation of a translog cost model, suggested by Pindyck (1979). This approach is based on neoclassical theory and assumes that factor and fuel inputs are chosen to minimize the total cost of production (Renou-Maissant, 1999). We assume that aggregate production is weakly separable in the major components of capital, labor, energy, and materials. Furthermore, we assume that each of the above factors is homothetic in their components, such that we can specify a homothetic translog fuel cost-share equation. Under these assumptions, the aggregate production function is given by:

$$Y = F\ [K, L, E\ (OI, NG, EL); M] \qquad (1)$$

where Y is gross domestic product, and K, L, E, and M represent the quantities of capital, labor, energy, and materials. Function E is a homothetic aggregate energy input function of three fuels, i.e., oil (OI), natural gas (NG), and electricity (EL). If the factor prices and output level are exogenously determined, the above production function can be described by a cost function which is weakly separable:

$$C = C\left[P_K, P_L, P_E(P_{OI}, P_{NG}, P_{EL}), P_M; Y\right] \qquad (2)$$

where P_i are the prices of factors and fuels. The translog functional form can be considered as a second-order approximation to the above arbitrary twice-differentiable cost function (Christensen et al., 1973):

$$\ln C = \alpha_0 + \alpha_Y \ln Y + \sum \alpha_i \ln P_i + \frac{1}{2}\beta_{YY}(\ln Y)^2 + \frac{1}{2}\sum\sum \beta_{ij} \ln P_i \ln P_j + \sum \beta_{Yi} \ln Y \ln P_i \qquad (3)$$

where *i, j* = K, L, E, and M. In Eq. (3), $\beta_{YY} = 0$ because of the assumption of homogeneity of degree one in price, $\sum \alpha_i = 1$ and $\sum \beta_{ij} = \sum \beta_{ji}$ because of the adding-up criteria, $\beta_{ij} = \beta_{ji}$ because of the Slutsky symmetry restriction, and $\sum \beta_{Yi} = 0$ because of the assumption of homotheticity in the production function (Cho et al., 2004). Using Shephard's lemma, the conditional factor demands is obtained by differentiating Eq. (3) with respect to input prices:

$$\frac{\partial \ln C}{\partial \ln P_i} = \frac{\partial C}{\partial P_i} \cdot \frac{P_i}{C} = \frac{P_i X_i}{C} = S_i^{factor} = \alpha_i + \beta_{Yi} \ln Y + \sum \beta_{ij} \ln P_j \qquad (4)$$

The homothetic translog aggregate energy-price index (P_E) function is given by:

$$\ln P_E = \alpha_0 + \sum \alpha_i \ln P_i + \frac{1}{2} \sum \sum \beta_{ij} \ln P_i \ln P_j \ , \qquad (5)$$

where P_E is the aggregated energy price and P_i or P_j denote the prices of oil, natural gas and electricity. By differentiating Eq. (5) with respect to individual fuel prices, the fuel cost-share equations are derived as follows:

$$S_i^{fuel} = \alpha_i + \sum \beta_{ij} \ln P_j \qquad i = EL, NG, OI \qquad (6)$$

It is clear that in the two-stage estimation approach, we must estimate the system of homothetic translog fuel cost-share functions first to compute the fitted aggregated energy price $(\hat{P}_E)$. Through the estimation of Eq. (6), the partial own- and cross-price elasticities of the fuels can be derived. In the second stage, by knowing the price indices of all factors, we can estimate the nonhomothetic translog factor cost-share equations (Eq. (4)). The Allen partial elasticities (σ_{ii} and σ_{ij}), and own-price and cross-price partial elasticities of fuel demands (η_{ii} and η_{ij}) are given by (Allen, 1938):

$$\sigma_{it} = \frac{\beta_{it} + S_i (S_i - 1)}{S_i^2} \ \ and \ \ \sigma_{it} = \frac{\beta_{it} + S_i S_j}{S_i Sj} \quad \forall \neq j, \qquad (7)$$

$$\eta_{ii} = \sigma_{ii} S_i \ \text{and} \ \eta_{ij} = \sigma_{ij} S_j \quad \forall i \neq j \ , \qquad (8)$$

where i and j are oil, natural gas, and electricity and S_i and S_j are the cost shares of fuels. To control for technological progress and structural change in the postwar era, two other fuel cost-share models are specified. The first is a static model with a time trend (Eq. (9)) and the other is the first-difference model (Eq. (10)). The time trend captures not only the technological progress in the economy, but also the effects of the economic reconstruction and boom that occurred after the Iran–Iraq war in 1988. While the first-difference variables reflect the changes in variables, the first-difference model can show the short-term impacts (where the economic and structural variables are relatively more stable).

$$S_i^{fuel} = \alpha_i + \sum \beta_{ij} \ln P_j + \gamma_{it} t \tag{9}$$

$$\Delta S_i^{fuel} = \alpha_i + \sum \beta_{ij} \Delta \ln P_j \tag{10}$$

3. Estimation Results

To estimate the fuel cost-share equations, we employed annual data over the period 1990–2013. The period was shortened because of the Iran–Iraq war (the First Persian Gulf War) from September 1980 to August 1988. In this period, the Iranian economy experienced substantial damage, instability and structural breaks. To avoid estimation bias, we only measure the substitution elasticities in the postwar era. The nominal prices and final consumption of electricity, natural gas, and oil products were collected from the Energy Balance of Iran 2013 (MoE, 2014). The CPI is derived from the database of the Central Bank of Iran (CBI, 2016). The price index of oil is the weighted sum of the prices of the oil products.

3.1. The fuel model

Employing the seemingly unrelated regression (SUR) method, introduced by Zellner (1962), we estimate the system equations of the translog fuel cost-share function. Table 1 reports the estimation results of the static model without a time trend [Eq. (6)], the static model with a time trend [Eq. (9)], and the first-difference model [Eq. (10)]. As Table 1 shows, all the coefficients except $\beta_{NG.OI}$ in the first model are highly significant.

Table 1: Parameter Estimation of the Translog Fuel Cost-share Equations

Coefficient	Static model without time trend (Model 1)	Static model with time trend (Model 2)	First difference (Model 3)
α_{EL}	–0.055 (0.023)	–12.216 (0.628)	0.008 (0.003)
α_{NG}	0.310 (0.025)	–8.140 (0.424)	0.006 (0.002)
α_{OI}	0.724 (0.024)	21.435 (0.774)	0.995 (0.003)
$\beta_{EL.EL}$	0.217 (0.016)	0.240 (0.009)	0.248 (0.010)
$\beta_{EL.NG}$	–0.079 (0.011)	–0.073 (0.008)	–0.050 (0.008)
$\beta_{EL.OI}$	–0.140 (0.022)	–0.190 (0.004)	–0.210 (0.009)
$\beta_{NG.NG}$	0.090 (0.015)	0.084 (0.005)	0.082 (0.007)
$\beta_{NG.OI}$	–0.013 (0.017)	–0.050 (0.005)	–0.029 (0.006)
$\beta_{OI.OI}$	0.152 (0.031)	0.244 (0.012)	0.230 (0.010)

Source: Research findings. *Note:* Numbers in parentheses are the standard errors. NG=Natural gas, EL=Electricity, OI=Oil.

Table 2 represents the estimated Allen and price partial elasticities. Obviously, the estimated elasticities in the static model without a time trend are significant at 10%. However, adding the time trend to Eq. (9) makes the

Allen - and own-price elasticities of electricity ($\sigma_{EL.EL}$ and $\eta_{EL.EL}$) insignificant. In the last model, four out of 15 elasticities are insignificant, which are the Allen- and own-price elasticities of electricity and natural gas ($\sigma_{EL.EL}$, $\sigma_{NG.NG}$, $\eta_{EL.EL}$ and $\eta_{NG.NG}$). Among the significant own-price elasticities, the elasticities of electricity and oil are negative, whereas the elasticity of natural gas is positive. The results reveal that if the real price of electricity increases twofold, the demand for it reduces by 8.8%. The same increase in the oil price results in a 3.5% to 22.4% reduction in its demand. The story for natural gas is the opposite. If the reform raises the real price of natural gas by 100%, its demand increases by 25.3% to 33.1%. This finding is in contrast to the findings of some developing countries. For instance, Cho et al. (2004) and Ma et al. (2009) found that the own-price elasticities of all fuels are negative in Korea and China, respectively. Increasing the accessibility of users to natural gas through 189,484 km of pipelines, and relative cheapness, reliability of supply, and comfort in consumption, have been the main drivers of increasing natural gas consumption over the period of study. However, the sub-period analysis in the next section will show that the sensitivity of consumers to natural gas prices has changed. Overall, the above results show that fuel demands are inelastic with respect to their own prices.

The Allen- and cross-price elasticities suggest that electricity and natural gas were complementary and electricity and oil were substitutable over the period of study. The substitutability between oil and electricity is confirmed for most developed and developing countries (Pindyck, 1979; Cho et al., 2004; Ma et al., 2009). However, several studies carried out at the national level indicate long-run substitutability between gas (LPG and LNG) and electricity in developed countries (Renou-Maissant, 1999). For natural gas and oil, Models 1 and 3 confirm the substitutability of the fuels, while the second model suggests they are complementary. Some studies find substitutability between oil and gas (Perkins, 1994). Comparison of the cross-price elasticities reveals some interesting points. Although electricity and natural gas are complementary, the sensitivity of natural gas demand to the price of electricity is significantly higher than the sensitivity of electricity demand to the price of natural. In addition, the sensitivity of oil demand to the electricity price is almost the same as the sensitivity of electricity demand to the oil price.

Table 2: The Allen and Price Partial Elasticities of Fuels

Elasticity	Static model without time trend (Model 1)	Static model with time trend (Model 2)	First difference (Model 3)
$\sigma_{EL.EL}$	–0.200 (0.075)	–0.058 (0.040)	0.020 (0.050)
$\sigma_{EL.NG}$	–1.480 (0.340)	–0.570 (0.250)	–0.570 (0.240)
$\sigma_{EL.OI}$	0.390 (0.083)	0.142 (0.035)	0.070 (0.044)
$\sigma_{NG.NG}$	3.572 (2.001)	4.700 (1.750)	1.823 (1.512)
$\sigma_{NG.OI}$	0.740 (0.400)	–0.200 (0.111)	0.237 (0.145)
$\sigma_{OI.OI}$	–0.429 (0.121)	–0.079 (0.031)	–0.091 (0.050)
$\eta_{EL.EL}$	–0.088 (0.031)	–0.031 (0.026)	0.021 (0.013)
$\eta_{EL.NG}$	–0.125 (0.025)	–0.049 (0.007)	–0.055 (0.020)
$\eta_{EL.OI}$	0.201 (0.047)	0.081 (0.012)	0.043 (0.026)
$\eta_{NG.EL}$	–0.631 (0.150)	–0.245 (0.089)	–0.241 (0.101)
$\eta_{NG.NG}$	0.233 (0.144)	0.350 (0.100)	0.141 (0.121)
$\eta_{NG.OI}$	0.407 (0.200)	–0.097 (0.053)	0.128 (0.073)
$\eta_{OI.EL}$	0.170 (0.045)	0.072 (0.011)	0.033 (0.021)
$\eta_{OI.NG}$	0.043 (0.038)	–0.014 (0.010)	0.028 (0.012)
$\eta_{OI.OI}$	–0.224 (0.056)	–0.035 (0.021)	–0.050 (0.030)

Source: Research findings. *Note:* Numbers in parentheses are the standard errors. Elasticities are computed using the mean of each share. NG=Natural gas, EL=Electricity, OI=Oil.

3.2. The sub-period analysis

The sub-period analysis provides a clearer image about the behavior of energy consumers. The results show that the own-price elasticities of oil and electricity were extremely stable over the period of study. For almost the whole period, the elasticities were negative and close to zero. In other words, the demand for oil and electricity were inelastic with respect to their prices in the last two decades. The demand for natural gas shows a different picture. The own-price elasticity of natural gas was positive until 2007 and then completely elastic in the years following the end of war. However, the elasticity reduced over time with some fluctuations and finally, became negative in the last years of our study. That is, the sensitivity of consumers to the price of natural gas has increased gradually.

As the target of this study is the assessment of the effects of energy subsidy reform on fuel demand in Iran, the elasticities of fuels should be determined cautiously. Therefore, in addition to the average elasticities in Table 2, we calculate the averages of recent elasticities reflecting the shift in Iranian consumer behavior. Table 3 represents the average elasticities for the period 2007–2013.

Table 3: Average Price Elasticities for the Period 2007–2013

Elasticity	Static model without time trend (Model 1)	Static model with time trend (Model 2)	First difference (Model 3)
$\eta_{EL.EL}$	–0.08	–0.02	0.02
$\eta_{EL.NG}$	–0.08	–0.01	–0.01
$\eta_{EL.OI}$	0.16	0.02	–0.02
$\eta_{NG.EL}$	–0.28	–0.02	–0.03
$\eta_{NG.NG}$	–0.12	–0.09	–0.30
$\eta_{NG.OI}$	0.43	0.10	0.24
$\eta_{OI.EL}$	0.11	0.02	–0.01
$\eta_{OI.NG}$	0.10	0.03	0.06
$\eta_{OI.OI}$	–0.23	–0.04	–0.05

Source: Research findings. *Note:* NG=Natural gas, EL=Electricity, OI=Oil.

The temporal change in the price elasticities of fuels reflects the temporal changes in their substitutability and complementarity. The results reveal the stable pattern of substitutability between natural gas and oil, and, electricity and oil. Although natural gas and electricity were complementary over the whole period, their Allen partial elasticities decreased gradually. Given the reducing degree of complementarity between natural gas and electricity, we can estimate that if this trend continues, these two fuels will become substitutable in coming years.

5. Fuel Conservation Effects of the Reform

As mentioned above, Iran started to remove fuel subsidies in successive phases in 2010. Article 1 of the Subsidy Reform Law requires that the domestic sale prices of energy carriers should adjust gradually until the end of the Fifth Five-Year Development Plan (2010–2015) to a level not less than 90% of Persian Gulf FOB[1] prices. However, it is not clear when and in how many steps the next phases of reform will proceed.

Table 4 provides information on domestic and regional retail energy prices before and after the reform. Clearly, the gap between domestic and regional prices in Iran has been considerable in some of the years. Before implementation of the reform, the ratios of international prices to domestic prices for electricity, natural gas, gasoline, kerosene, gas oil, fuel oil, and LPG were 4.68, 22.96, 5.36, 38.7, 37.81, 41.49, and 11.49, respectively. In the first phase of the reform, from December 2010, the government increased the domestic retail prices of these same fuels by 173%, 570%, 300%, 506%, 809%, 2016%, and 426%, respectively.

1. Freight on board (FOB).

Table 4: Domestic and Regional Retail Energy Prices Before and After the Reform (IRR)

	Domestic energy prices in 2009/10 (before reform)	Average regional market prices in 2009/10	Increase in nominal prices (%)	Domestic energy prices in 2010 (after reform)	Increase in nominal prices (%)
Electricity	165	773[a]	368	450	173
Natural gas	104.5	2400[b]	2197	700	570
Gasoline	1000	5362[c]	436	4000	300
Kerosene	165	6392[c]	3774	1000	506
Gas oil	165	6239[c]	3681	1500	809
Fuel oil	94.5	3921[c]	4049	2000	2016
LPG	309.1	3605[c]	1066	1625	426

Source: MoE (2014) and MoP (2014). Note: 1 USD = 9,917 IRR in 2009/2010.
Note: [a] Export price (IRR/kWh), [b] Export price (IRR/m^3), [c] FOB price of refined petroleum products in the Persian Gulf (IRR/liter)

Using the estimated own- and cross-price elasticities of fuels, we can estimate the reduction in energy demand in the next step. As explained above, the elasticities measure the percentage change in fuel demand following a 1% increase in the real price of the same fuel or of other fuels. Table 4 shows the percentage changes in fuel prices after implementation of the energy subsidy reform in Iran. To measure the impact of the reform on energy conservation correctly, we need to know the inflationary impact of the reform. The following example highlights the necessity of knowing the increase in the general price level of goods and services. If increasing the price vector of fuels by 10% increases the aggregate price index by the same amount, the real prices of fuels do not change and consequently the demand pattern of consumers remains unchanged.

Using the estimated own- and cross-price elasticities of electricity, natural gas, and oil illustrated in Tables 2 and 3, and considering the percentage changes in real fuel prices in the first phase and overall energy subsidy reform period, we calculate the percentage changes in fuel demands in Iran. To avoid any bias in the calculations, we replace the significant elasticities of electricity and natural gas with the insignificant ones in the second and third models. Table 5 shows the percentage changes in fuel demands after the implementation of the reforms. Table 5 is divided into four parts. Parts I and II show the percentage changes in the first phase and overall reform period using the averaged elasticities over the period 1990–2013. Parts III and IV show the changes using the averaged elasticities over the period 2007–2013.

Table 5: Changes in Fuel Demands of Iranian Consumers in the First Phase and Overall Reform Period (percentage)

	1990–2013					
	First phase			**Complete reform**		
	Model 1	**Model 2**	**Model 3**	**Model 1**	**Model 2**	**Model 3**
Electricity	+16.005	–6.254	–18.421	–14.521	–27.100	–50.214
Natural gas	+175.244	+90.012	+127.821	+520.222	+341.781	+402.001
Oil	–40.069	–13.776	–7.521	–65.000	–41.251	–8.002
	2007–2013					
Electricity	+17.452	–7.127	–20.257	+0.995	–15.741	–40.609
Natural gas	+60.120	+0.807	+32.281	+80.005	–31.054	+3.521
Oil	–28.010	–3.444	+7.500	–21.854	+6.874	+37.001

In all parts, Model 1 shows larger changes because of the higher elasticities. In addition, the direction of changes is similar in Models 2 and 3. In Part I and Model 1, implementing the first phase would increase the demand for electricity and natural gas by 16% and 175%, respectively. It also reduces the demand for oil by 40%. In contrast, Model 2 shows that the first phase results in 6% and 13% reductions in electricity and oil demands, respectively, and a 90% increase in the demand for natural gas. Model 3 estimates a larger reduction in the demand for electricity than for oil (18% vs 7%). Adjusting the elasticities, Part 3 shows a smaller increase in the demand for natural gas. In Model 1, the demand for electricity and natural gas increases by 17% and 60%, respectively. The only conservation effect of the reform is a 28% reduction in oil demand. Model 2 shows minor changes in demands after controlling for any dynamic effects using a time trend. Decreases in the demand for electricity and for oil of 7% and 3%, respectively, is the only outcome of applying the fuel price changes in the first phase. Finally, Model 3 shows increases in the demand for oil and natural gas of about 7.5% and 32%, respectively, whereas the demand for electricity decreases by 20%.

Different models show contradictory results about the conservation effects of full subsidy reform in Iran. Model 1 in Part II demonstrates that the reform reduces the demand for electricity and for oil by 14% and 65%, respectively. However, it increases natural gas demand by about six times. Reductions of 27% and 41% in the demand for electricity and for oil, respectively, are the outcome of Model 2. On the contrary, it increases the demand for natural gas by 341%. Model 3 provides similar results, with estimates of the increase in the demand for natural gas of 402% and decreases in electricity and oil demand of 50% and 5%, respectively. If we consider the recent behavioral sensitivity of consumers in Part IV, we obtain more optimistic results. In Model 1, the full reform has no significant impact on electricity demand. In contrast, it raises the demand for natural gas by 80% and reduces the demand for oil by 21%. Model 2 provides the most optimistic results among all models. Based on the results of Model 2, the full reform reduces the demand for electricity and natural gas by 15% and 31%, respectively. In contrast, it increases the demand for oil by 7%. In Model 3, the demand for electricity falls by 40%. However, it increases the demand for natural gas and for oil by 3% and 37%, respectively.

From a methodological point of view, the elasticities for the period 2007–2013 better reflect the actual behavior of consumers, thus providing estimates that are more accurate. Consequently, the results in Parts III and IV are superior to the results in Parts I and II. The most optimistic results in Part III are from Model 2, which estimates 7% and 3% reductions in electricity and oil demand, respectively, and a marginal increase in natural gas demand after implementation of the first phase of reform. These results show a marginal impact of the first phase on energy consumption in Iran. However, if we consider the results of Models 1 and 3, we can conclude that the reform never reduces total energy demand, but rather will increase it. The same as for Part III, Model 2 provides the most hopeful results for the overall reform scenario. It diminishes the demand for electricity and for natural gas by 15% and 31%, respectively, but increases the demand for oil by 7%. However, the results of the two other models are disappointing. They show that either the full liberalization of energy prices has no significant effects (Model 3) or it increases total energy demand (Model 1). In general, the results reveal that the reform may not be as successful as imagined previously. Under an optimistic view, it conserves energy marginally. Under a pessimistic view, it may increase energy demand because of inelastic demands and substantial substitution between fuels.

6. Conclusion

This paper is an attempt to measure the fuel conservation effects of energy subsidy reform in Iran. To measure the impact of the first phase and overall reform on energy demand in Iran, a translog cost function of the energy market was estimated and the own- and cross-price elasticities of electricity, natural gas, and oil were derived. The results of this study can be summarized in the following points.

First, the own-price elasticities of electricity and oil are negative and the own-price elasticity of natural gas is positive over the period of study. Second, electricity and natural gas are complements and electricity and oil are substitutes over the period of study. In addition, most of the models find substitutability between natural gas and oil. Third, the own-price elasticities of oil and electricity are highly stable and close to zero over the period of study. However, the positive elasticity of natural gas declines over time and becomes negative in the last years of our study.

Finally, we found that the reform might not hit its targets. Under an optimistic view, the reform may conserve energy marginally, and under a pessimistic view, it may increase energy consumption because of inelastic fuel demands and substantial substitution between them. As a policy implication, the above results suggest that other conservation strategies, such as training, technological progress and regulation improvement, etc., are alternatives to the price reform policy.

From a social perspective, the unsatisfactory conservation outcome of the reform should be considered alongside the effects of the reform on key economic, social, and environmental variables. If we consider the total impact of the reform, we can evaluate its sustainability in Iran. The question of the sustainability of the reform is one that should be answered in future studies.

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Appendix

Gross Domestic Product and Energy Consumption in Iran (1990–2013)

Year	GDP, PPP (billion, constant 2011 international $)	GDP percapita, PPP (constant 2011 international $)	GDP growth (%)	Energy consumption (MBOE)									Energy intensity (BOE/1000 USD, PPP)	CO2 intensity (tons/1000 USD, PPP)
				Residence, public, commerce	(%)	Industry	(%)	Transportation	(%)	Agriculture	(%)	Total		
1990	571.45	10,173.68	13.59	141.63	41.81	66.95	19.76	98.32	29.02	31.89	9.41	338.78	0.59	0.37
1991	644.11	11,243.42	12.72	158.56	42.41	72.95	19.51	109.28	29.23	33.11	8.86	373.90	0.58	0.35
1992	665.36	11,445.98	3.30	189.99	45.87	77.34	18.68	117.14	28.29	29.68	7.17	414.15	0.62	0.34
1993	655.57	11,146.88	-1.47	205.90	45.85	83.37	18.57	131.35	29.25	28.40	6.32	449.02	0.68	0.36
1994	644.44	10,830.61	-1.70	218.36	45.29	89.87	18.64	138.55	28.74	35.34	7.33	482.11	0.75	0.41
1995	659.91	10,940.37	2.40	220.70	44.72	104.67	21.21	136.97	27.76	31.15	6.31	493.48	0.75	0.41
1996	701.82	11,447.64	6.35	231.47	44.13	114.28	21.79	147.93	28.21	30.79	5.87	524.46	0.75	0.39
1997	711.29	11,394.17	1.35	242.12	43.92	126.23	22.90	153.22	27.80	29.67	5.38	551.24	0.77	0.38
1998	726.09	11,413.60	2.08	241.10	43.52	118.54	21.40	161.20	29.10	33.14	5.98	553.98	0.76	0.43
1999	740.63	11,432.93	2.00	252.48	43.24	131.01	22.43	170.20	29.15	30.27	5.18	583.95	0.79	0.52
2000	783.92	11,904.67	5.85	272.11	43.87	134.02	21.61	183.37	29.56	30.77	4.96	620.27	0.79	0.48
2001	802.68	12,013.82	2.39	278.29	43.64	134.97	21.16	194.13	30.44	30.37	4.76	637.75	0.79	0.5
2002	867.52	12,814.85	8.08	306.17	44.69	140.49	20.51	209.01	30.51	29.36	4.29	685.03	0.79	0.46
2003	942.47	13,754.27	8.64	316.67	43.78	154.31	21.33	220.82	30.53	31.59	4.37	723.39	0.77	0.44
2004	983.34	14,185.16	4.34	345.01	44.44	165.20	21.28	234.03	30.14	32.17	4.14	776.41	0.79	0.46
2005	1,024.73	14,613.49	4.21	371.70	44.58	181.33	21.75	247.00	29.63	33.70	4.04	833.73	0.81	0.46
2006	1,083.18	15,272.61	5.70	413.20	45.54	194.34	21.42	263.00	28.99	36.80	4.06	907.34	0.84	0.47
2007	1,181.93	16,479.53	9.12	436.50	44.91	236.05	24.29	261.70	26.93	37.60	3.87	971.85	0.82	0.44
2008	1,192.84	16,446.05	0.92	417.40	42.33	252.74	25.63	274.00	27.79	41.90	4.25	986.04	0.83	0.46
2009	1,220.45	16,634.02	2.31	431.90	41.78	258.05	24.96	300.50	29.07	43.30	4.19	1033.75	0.85	0.46
2010	1,300.73	17,517.43	6.58	424.10	41.00	281.52	27.22	283.20	27.38	45.50	4.40	1034.32	0.80	0.44
2011	1,349.50	17,949.24	3.75	432.40	40.79	293.58	27.70	288.20	27.19	45.80	4.32	1059.98	0.79	0.43
2012	1,260.32	16,548.94	-6.61	407.52	38.46	303.54	28.65	300.87	28.40	47.57	4.49	1059.50	0.84	0.46
2013	1,236.23	16,023.15	-1.91	440.74	39.95	301.87	27.36	311.03	28.19	49.61	4.50	1103.26	0.89	0.49

Source: WDI (2016) and MoE (2014)