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Estimating the Demand for Diesel in Agriculture Sector of Iran

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ABSTRACT

This paper estimates per capita demand for diesel by agricultural sector in Iran using auto-regressive distributed lags method over 1973-2012. The findings indicate that the demand for diesel is relatively inelastic in response to changes in its price, electricity acts as substitute input for diesel, diesel is a necessary input in agriculture, and mechanization index, despite having expected positive sign, fails to explain variations in diesel use. In addition, there is a long-run relationship among variables. According to error correction model, the speed of adjustment in short-run distortions towards long-run equilibrium is moderate. The findings show that government policy on cutting energy subsidies is not enough for reducing diesel consumption in Iranian agricultural sector. Thus, non-price measures such as innovations in inter-fuel substitution technologies and applying efficient machineries are recommended to manage energy uses in agriculture.

Keywords: Demand, Price, Diesel, Electricity, Auto-Regressive Distributed Lags
JEL Classifications: C51, Q16, Q41

1. INTRODUCTION

In Iran, the agriculture is of great importance due to its contributions to the national economy through employment creation, investment promotion, food provision, and poverty reduction in rural areas. In 2012, agriculture and its subsectors including hunting, forestry, and fishery accounted for 19.4% of employed persons aged 10 years and over (SCI, 2012).

The use of diesel in Iranian agriculture compared to the commercial and industrial sectors is relatively high. According to the energy balance sheet of Iran, the share of diesel use in agriculture was 10.8% in 2012, whereas corresponding shares for commercial and industrial sectors were 0.65% and 6.68% in the same period, respectively. As well, the use of diesel in agriculture grew by 2.8% per annum over the period 1973-2012. In addition, diesel accounted for 92.8% of total oil products use during 1973-2012 (Iran Energy Balance Sheet, 2012). Figure 1 shows the overall increasing movements in diesel use in agriculture sector of Iran.

Agriculture sector of Iran has adopted mechanization process through changing energy use forms. In the 1970s, peasantry and rural farming units were consuming traditional fuels extensively; however, the fossil fuels and electricity uses have increased substantially in 2000s due to energy subsidies and transition to mechanized agriculture (Sabetghadam, 2006). Diesel consumption in agriculture takes various forms in different activities. All tillers and tractors, combines and water pumps use diesel for different purposes. For instance, tillers and tractors use diesel for land preparation, planting, harvesting, and transporting of farm products. In addition, diesel is consumed in producing crops and livestock on the farm and processing operations.

The pricing of diesel in the agricultural sector is just like pricing in the other sectors of national economy. Until 2010, all oil products were highly subsidized, so low nominal prices encouraged consumers to use them inefficiently in different sectors. The low diesel prices induced more farmers to use it for diversifying cultivation patterns, transporting farm products to markets, and producing food (Mehrabi Boshrabadi and Naqavi, 2011).

The nominal price of diesel (PD) was 1.83 cent/L in 2005[1], while it jumped to 21 cent/L in 2010[2] (Iran Energy Balance Sheet, 2012). The increases in diesel price caused rapidly rising costs of agricultural production. For example, delays in handling

1 1 US $= 9023 Iranian Rial (official exchange rate, yearly average)
2 1 US $= 10337 Iranian Rial (official exchange rate, yearly average)

agricultural products, which are attributable to high freight fees, increased the cost of production of farm products. The real PD, defined as price ratio of diesel to consumer price index (CPI), acts as a main factor affecting diesel use in agriculture. A glance at Figure 2 indicates that the real diesel price was nearly 50 Iranian Rials/L until recent years; however it jumped to over than 300 Iranian Rials/L in 2011 due to government policy on cutting energy subsidies.

Electricity ranks at the second place after diesel in providing energy requirements in agriculture. In particular, some agro-industrial processes have been designed in such a way that they can make use of competing fuels especially for heating purposes. Hence, it is necessary to track the movements in electricity tariffs in agriculture. Figure 3 exhibits the real price of electricity (PE) over the 1973-2012.

Evidently, the agricultural activities especially farming are dependent on land and its physical and chemical characteristics such as soil fertility, intensity of farm inputs, rainfall, etc. While extensive agriculture relies on vast land areas, the intensive agriculture is identified by the more use of inputs such as machinery, pesticides, and chemical fertilizers relative to land area. Due to difficulty in measuring mechanization and lack of data on various agricultural machinery, the number of tractors per 100 km^2 of arable land is used as a proxy for mechanization index (mechindex) in this paper. This indicator is obtained from the World Bank. As Figure 4 illustrates, use of tractors in Iran's agricultural sector has increased over time.

According to Iranian agriculture mechanization database[3], the number of operative tractors amounted to 389,536 in 2009. More than 85% of tractors are medium-sized with 33.5-59.6 kW power. In addition, the age of half of the operating tractors is over 13 years, and most of them are outdated. With existing tractors, light farm operation is completed with loss of energy, and heavy operation is made by low quality. Each tractor in modest circumstances of its lifecycle consumes about 12-13 L of diesel/h.

The Central Bank of Iran (CBI) estimates agricultural activities value-added in five areas: farming, animal husbandry and hunting, fishing, forestry and agricultural services. The overall achievements of agriculture can be summarized at value added figures. The annual changes of value-added indicate real economic growth of the sector, when they are valued at constant prices. Figure 5 illustrates a relatively increasing trend of real agriculture value added with average growth rate of 4.4% per annum.

The changes in energy prices result in the farmers reactions in supply side. The upward movements in energy prices involve expensive energy inputs for farmers and high costs. This paper focuses on only direct energy use in agriculture sector of Iran.

The rest of this paper is organized in three sections. Section 2 gives a review of literature. Section 3 provides the materials and methods. Finally, Section 4 devotes to conclusions.

2. REVIEW OF LITERATURE

The energy use in agriculture takes two direct and indirect forms. Direct use of fossil fuels and electricity include the energy cost of producing different crops and animal products at different methods of agricultural production, such as traditional versus industrial agriculture. Indirect energy use in agriculture is the energy used

3 Available at website of Iranian Agriculture Mechanization Development Center: http://www.agmdc.ir

Figure 1: Diesel consumption by agriculture in Iran (million liters)

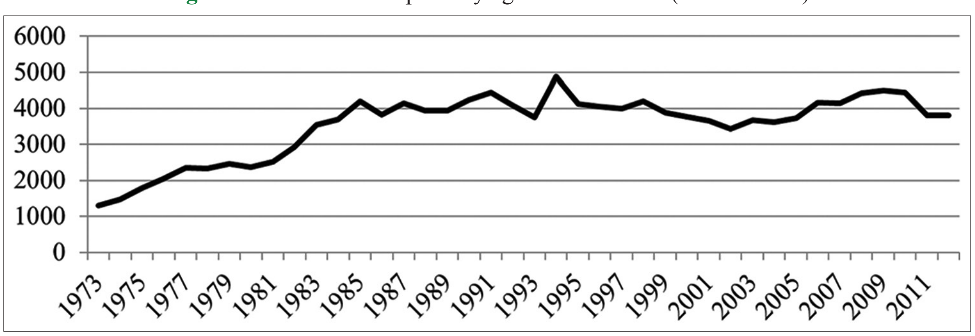


Figure 2: Real price of diesel in Iran (Iranian Rial/L, 1997=100)

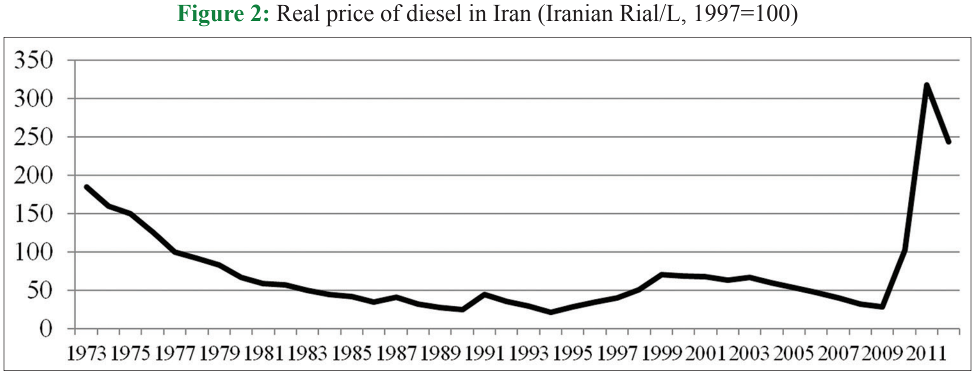


Figure 3: Real price of electricity in Iran (Iranian Rial/kWh, 1997=100)

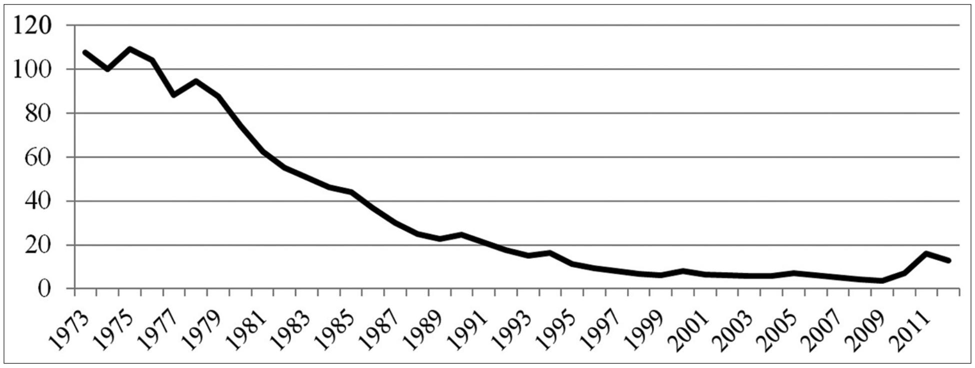


Figure 4: Trend of using tractors in Iran's agricultural sector (tractors per 100 km² of arable land)

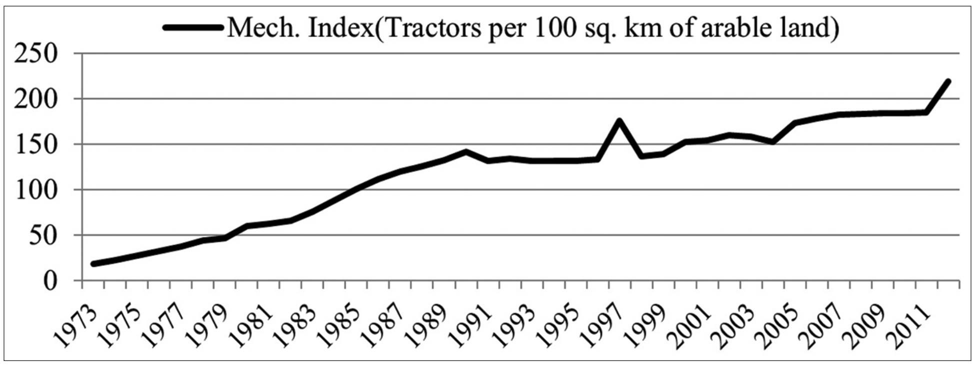
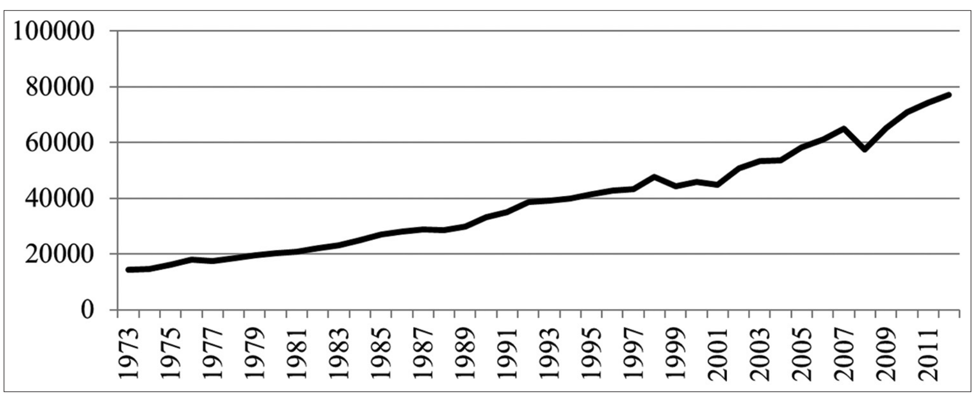


Figure 5: The real agricultural value-added in Iran (billion Iranian Rials, 1997=100)



off the farm to manufacture inputs such as fertilizer and farm machinery (Cleveland, 1995).

Generally, a translog cost function is applied in majority of studies on modeling energy and fuel demand (Woodland, 1975; Berndt and Wood, 1979; Debertin, et al., 1990; Christopoulos and Tsionas, 2002; Welsch and Ochsen, 2005). Ma et al. (2009) estimated the elasticities of the interfuel substitution and demand for the regional and aggregate economy using non-homothetic translog total factor cost function in panel data of 31 provinces for 1995-2004. Price elasticities for both diesel and electricity were absolutely less than one and substitution elasticity between them was positive at both national and regional level ranging from 0.65 to 0.74.

The existing texts make available numerous studies on the demand for energy carriers at various levels. Yu et al. (2014) have summarized some of the major works on demand for natural gas over the 1990s and 2000s in different data format (cross-sectional data, aggregated data and panel data). However, literature on demand for energy in agriculture is relatively poor. Turkekul and Unakitan (2011) estimated the elasticities of demand for diesel and electricity in Turkey over the 1970-2008 using cointegration and error correction model (ECM); and calculated the long-run income and price elasticity for the diesel demand model as 1.47 and −0.38. They found corresponding elasticities as 0.19 and −0.72 for the electricity demand model.

Baruah and Bora (2008) consider agricultural development and higher production as requirements for mechanization. They take supply of sufficient energy as a prerequisite for mechanized agriculture, investigate the energy demand, and supply scenarios with reference to some prospective mechanization strategies for rice crop in Assam of India. They conclude that the demand for diesel would increase with an associated decrease in manpower and reduction of bullock power.

Zaman et al. (2012) investigate the causal relationship between energy consumption and agricultural technology factors and compute electricity consumption and technological factors in the agricultural sector of Pakistan. They apply techniques of co-integration and granger causality tests on energy demand (i.e., total primary energy consumption and electricity consumption) and agricultural technology factors (such as, tractors, fertilizers, cereals production, agriculture irrigated land, high technology exports, livestock; agriculture value added; industry value added and subsides) over a period of 1975-2010. The results indicate that tractor and energy demand has bi-directional relationship; while irrigated agricultural land; share of agriculture and industry value added and subsides cause energy consumption in Pakistan. On the other hand, neither fertilizer consumption and high technology exports nor energy demands affect each other.

Uri (1979) examines the responsiveness of US agriculture to changes in the PE and estimates price and demand equations for electricity using data for 48 American states over the period 1975-1977. Based on price elasticity, he suggests market mechanism in curtailing demand.

Uri (1989a) studies the response the agricultural consumers of motor gasoline and diesel to changes in the relative prices of different types of energy by a demand model. He concludes that other types of energy are substitutes for motor gasoline and diesel, and income and weather (measured by cooling degree-days and heating degree-days) affect motor gasoline and diesel consumption.

Uri (1989b) studies the response of the agricultural consumers of natural gas to changes in the relative prices of different types of energy by a demand model. The conclusions strongly suggest that not only is the price of natural gas a factor impacting the quantity of natural gas demanded by agriculture, but that other types of energy are substitutes for natural gas and that income and weather (measured by heating degree days) likewise affect natural gas demand.

Pathak (1985) suggests a model for predicting the commercial energy demand of production agriculture of Punjab using quantitative data for the period 1965-1966 to 1979-1980 and report a linear relationship between commercial energy use and production.

With the help of a quadratic programming sector model of Saskatchewan agriculture, Tewari et al. (1989) demonstrate that rising energy-price impacts can be significantly different if producers face different levels of trade-demand elasticities. Although consumers would always lose because of rising energy prices under varying demand elasticities, this is not always the case with producers. Net returns to producers may increase even under a rising energy-price regime if they face very inelastic markets. Similarly, other energy price impacts are shown to differ significantly under varying demand elasticities.

Lu et al. (2011) analyze the situation of the energy consumption of Chinese agriculture over the period 1991-2008 and use the DoseResp growth curve for the energy scenario analysis of the future trend about the energy consumption of Chinese agriculture. The results of the research indicate that the energy consumption of Chinese agriculture conforms to the DoseResp growth curve.

Sebri and Abid (2012) examine the causal relationship between energy consumption and agricultural value added at both aggregated as well as disaggregated components of energy consumption, including oil and electricity, controlling for trade openness, in Tunisia from 1980 to 2007. Using Granger's technique, they show that that trade openness and both aggregated and disaggregated energy consumption granger causes agricultural value added. Therefore, shocks to energy supply would have a negative impact onto agriculture performance, and trade liberalization is a stimulus factor to the Tunisian agriculture development.

Ozkan et al. (2004) determine the energy use in the Turkish agricultural sector for the period of 1975-2000. With employing an input-output table, they indicate a decrease in the output-input energy ratio, i.e., the use of inputs in Turkish agricultural production is not accompanied by the same result in the final product.

3. MATERIALS AND METHODS

3.1. Data and Model

This study aims at estimating diesel use in agricultural sector of Iran. Based on empirical researches, the main variables affecting per capita diesel use are real PD, real PE, real per capita agriculture value-added (Y). The nominal prices are deflated by CPI 1997=100 to obtain real prices. The per capita variables are computed by dividing the level of variables into labor working in agriculture.

I apply annual data of above-mentioned of Iran's agriculture during 1973-2012. Data on labor, real value added and CPI are derived from CBI, while data on consumption and nominal prices of both diesel and electricity are extracted from energy balance sheet of Iran. Table 1 gives descriptive statistics on the variables. The most variability around mean, which is computed by coefficient of variation (CV), devotes to real electricity price, while per capita diesel use (Q) is of the least variability. These are not surprising since the electricity price changes often with overall changes in prices, i.e. inflation, so it is volatile, however, diesel use in agriculture is subject to technical innovations and farming patterns, and hence its variation is low. The other interesting finding is similarity between CVs of variables Q and Y, which means these behave equally over time.

In terms of review of literature, the following model is specified to determine factors influencing per capita diesel use:

$$\begin{aligned} Log\left(Q_t\right) &= \alpha_0 + \alpha_1 Log\left(PD_t\right) + \alpha_2 Log\left(PE_t\right) \\ &\quad + \alpha_3 Log\left(Y_t\right) + \alpha_4 Log\left(Mech_t\right) + \varepsilon_t \end{aligned} \tag{1}$$

Table 1: Descriptive statistics of variables

Variable	Mean	Median	Maximum	Minimum	SD	CV	Observations
PD (Iranian Rial/L)	73.18	52.22	318.4	21.6	61.9	0.85	40
PE (Iranian Rial/KWh)	34.26	16.98	109.4	3.65	34.9	1.02	40
Q (L/person)	927.11	923.29	1342.06	585.93	205.92	0.22	40
Y (Million Iranian Rial/person)	9.50	9.26	15.57	6.39	2.21	0.23	40
Mech (Tractors per 100 km^2 of arable land)	120.88	132.50	219.44	18.74	54.36	0.45	40

PD, PE, Q, Y and Mech represent real diesel price, real electricity price, per capita diesel consumption, real per capita agriculture value-added, and mechanization index, respectively. SD: Standard deviation, CV: Coefficient of variation, PD: Price of diesel, PE: Price of electricity

In which α_0 is intercept term, t denotes time and Log is natural logarithm. Taking variables in logarithmic form helps to obtain partial elasticities in terms of explanatory variables, so α_i (i = 1,2,3,4) represent elasticities of per capita diesel use (Q) with respect to real PD, real PE, real per capita agriculture value-added (Y), and mechanization index, respectively. It is expected that real PD results in decreasing per capita diesel consumption, other things being equal, so, $\alpha_1<0$. The sign of α_2 can be positive (for substitution between diesel and electricity) or negative (for complementarity of diesel and electricity). Evidently, the high per capita value added of agricultural activities is of direct and positive impacts on demand for diesel. Thus, the expected sign of α_3 is positive. As well, mechanization would increase diesel use, because agricultural machineries often depend on diesel especially in preparing of land and transporting of farm products, hence the expected sign of α_4 is positive.

3.2. Estimation Results and Discussion

The first step in estimating a time series model is to determine the order of integration. Table 2 gives the results of augmented Dickey–Fuller (ADF) test (Said and Dickey, 1984). If the absolute value of ADF is greater than MacKinnon (1996) critical values, the null hypothesis indicating unit root in series will be rejected. The results of the unit root tests show that all variables except for *Log(Mech)* have unit root in the level; however, they become stationary in logarithmic forms by the first differencing. The *Log(Mech)* has no unit root. Hence, it is stationary over time. Since all variables of interest are I(1), or I(0), therefore, the auto-regressive distributed lags (ARDL) approach to co-integration is applicable. Pesaran and Shin (1999) and Pesaran et al. (2001) developed the ARDL co-integration approach, which has three main characteristics: (1) the ARDL does not require the same order of integration of the variables under study. (2), the ARDL test is relatively more efficient in the case of small and finite sample data sizes and (3) the ARDL technique results in unbiased estimates of the long-run model (Harris and Sollis, 2003). Table 3 represents the estimation results of dynamic short-run model based on Microfit 4 (Pesaran and Pesaran, 1997) output.

Testing for co-integration is based on the following null and alternative hypotheses:

$$H_0 : \sum_{1}^{p} a_i \geq 1$$

$$H_A : \sum_{1}^{p} a_i < 1$$

In which a is the coefficient of lagged dependent variable and i=1,2,3… indicates the order of lag. The null hypothesis means no co-integration. If the null hypothesis is rejected, then a long-run co-integrating relationship will be created. This test uses the following t-statistic:

$$t = \frac{\sum_{1}^{m} \hat{a}_i - 1}{\sum_{1}^{m} se(\hat{a}i)} \quad (2)$$

Where *se* denotes standard error. If the absolute value of computed t-statistic is greater than absolute value of Banerjee et al., (BDM) (1998) critical value, the null hypothesis will be rejected, and the variables under consideration will be co-integrated.

In the significance level of 1%, BDM critical value with four regressors and intercept term is −4.85 for 50 observations. Since the computed t-statistic (−4.98) according to equation (2) is greater than BDM critical value in absolute term, then a long-run relationship among dependent and explanatory variable is confirmed. The results show that coefficients of lagged *Log(Q)*, *Log(PD)* and *Log(Y)* have the expected signs and are statistically meaningful. According to the results, 1% increase in lagged diesel consumption raises the current per capita consumption of diesel by about 0.51%, other things being equal. This finding denotes rigidity in consumption of diesel in agricultural sector of Iran. In other words, the Iranian farmers have not enough possibilities to adopt modern energy-saving systems. Partly, this fact originates from low incomes in agriculture. The other reason may be small size of land area, which does not allow farmers to exploit expensive and modern energy-saving technology. According to the latest census of agriculture in Iran (SCI, 2003), about 72.5% of *agricultural holdings*[4], which occupied 19.5% of the agricultural land, were <5 ha. In this land area category, more than 2.5 million agricultural holdings operated on 3.4 million hectares. Hence, average land area was almost 1.36 ha per agricultural holding.

In addition, if real PD increases by 1%, the diesel consumption will decrease by 0.16%. The sign of coefficient of Log(PE) reveals that electricity may be substituted for diesel in agricultural production processes, because the cross-price elasticity of diesel with respect to changes in real electricity price is almost 0.13 and positive, while it is significant at 1% significance level. Moreover,

4 An agricultural holding is the economic unit under a single management engaged in agricultural production activities (OECD, 1999). One or more agricultural activities operated by one or more persons form an agricultural production unit, called an agricultural holding (SCI, 1997).

elasticity of diesel consumption with respect to changes in real agriculture value added (Y) is about 0.37. Since agriculture value added is treated as a proxy for income, therefore diesel would be a necessary input in agriculture.

According to Table 3, while the coefficient of *Log(Mech)* has the expected sign, however it suffers from immaterial effectiveness on *Log(Q)*. This result is not startling, because I focused merely on stock of tractors to measure mechanization trend. Of course, this emphasis is inevitable due to lack of valid data on agricultural machinery time series. Nevertheless, utilizing machineries in agriculture would increase production and income of farmers. Therefore, if farmers tend to maximize their incomes, they may demand more diesel for fueling machineries in aggregate level. With reference to mechanization, Mehrabi Boshrabadi and Naqavi (2011) showed that mechanization affected negatively demand for diesel in Iran agriculture over the period 1974-2007. In their views, if use of agricultural machinery increases, then diesel use will decrease in the short-run. They attributed this relationship to modern and efficient agricultural machines, which consume diesel economically. This conclusion may be controversial, because number of tractors, as a measure for mechanization, has increased in Iran over time. In this situation, aggregate agriculture demand for diesel would likely increase, even we cynically assume that designing and producing technology of tractors remains unchanged in the long run.

The measures of goodness of fit, R^2, *F*-statistic and Durbin's *H*-statistic indicate the robustness of the obtained results. According to Table 4, the diagnostic tests point to correct specification of the model estimated, normality of residuals, lack of serial correlation, and homoscedasticity of residuals.

Table 2: Unit root tests

Variables	Level: constant and trend		First difference: constant and trend		Result
	ADF test statistic	*P*	ADF test statistic	*P*	
Log (Q)	−2.694	0.245	−6.509	0.000	I (1)
Log (PD)	−1.821	0.676	−5.751	0.000	I (1)
Log (PE)	0.755	0.999	−5.317	0.000	I (1)
Log (Y)	−1.843	0.664	−6.056	0.000	I (1)
Log (Mech)	−3.803	0.0005	-	-	I (0)

ADF: Augmented Dickey-Fuller, PD: Price of diesel, PE: Price of electricity

Table 3: ARDL(1,0,0,0,0) estimates selected based on Schwarz Bayesian criterion

Dependent variable is *Log (Q)*		SE	Time period: 1974-2012
Regressor	Coefficient		*t*-ratio [*P*]
Log (Q(−1))	0.507	0.099	5.102 [0.000]
Log (PD)	−0.162	0.034	−4.787 [0.000]
Log (PE)	0.132	0.038	3.428 [0.002]
Log (Y(	0.368	0.133	2.765 [0.009]
Log (Mech)	0.006	0.075	0.081 [0.936]
C	2.778	0.543	5.122 [0.000]
R-squared=0.889			*R*-bar-squared=0.873
F-statistic			Durbin's
F (5,33)=53.139 [0.000]			*H*-statistic=−1.332 [0.183]

SE: Standard error, PD: Price of diesel, PE: Price of electricity, ARDL: Auto-regressive distributed lags

Table 5 reports the estimation results of the long-run model of demand for diesel. Accordingly, the long-run own-price and cross-price elasticities, and long-run income elasticity are −0.33, 0.27, and 0.75, respectively. In addition, all long-run coefficients are statistically significant.

These findings are comparable with international studies, which focus on demand for energy in agriculture. For example, Turkekul and Unakitan (2011) found that the price elasticity of diesel was −0.79 in the short-run, however the corresponding elasticity was −0.38 in the long-run. In their research on Turkish agriculture, the magnitudes of the short-run and the long-run price elasticities seem to be contradictory, because microeconomic foundations imply that consumers are more responsive to price changes in the long-run, which result in greater price elasticities in absolute values. In addition, they estimated diesel income elasticities at 0.04 and 1.47 in the short-run and long-run, respectively, and concluded that the level of income has more effect on demand in the long-run. This is not surprising, because of Turkey dependency on imports of petroleum products, in particular, diesel. In the case of Iran, both the short-run and long-run income elasticities are smaller than one, which point to be necessary of diesel in Iranian agricultural sector. In other words, Iranian farmers are less responsive to changes in incomes. This fact roots in two realities of energy consumption in Iran. First, all consumers in general, and farmers in particular use various energy carries in wasteful ways, which originates from historical low fuel prices. Second, fluctuations in prices of agricultural products are heavily affect farmer incomes, however the income gains or losses are compensated by changes in consumption pattern of farmers. In other words, in Iran, farmers are forced to allocate more resources to meet basic needs in inflationary environment, so they inevitably cut secondary needs such as diesel.

In comparison of these results with Baruah and Bora (2008) findings, the same effect of mechanization on demand for diesel

Table 4: Diagnostic tests for ARDL (1,0,0,0,0)

Test statistics	LM version	*F* version
Serial correlation[A]	CHSQ (1)=1.848 [0.174]	*F* (1,32)=1.592 [0.216]
Functional form[B]	CHSQ (1)=0.578 [0.447]	*F* (1,32)=0.482 [0.493]
Normality[C]	CHSQ (2)=1.344 [0.511]	Not applicable
Heteroscedasticity[D]	CHSQ (1)=1.868 [0.172]	*F* (1,37)=1.861 [0.181]

[A]Lagrange multiplier test of residual serial correlation, [B]Ramsey's RESET test using the square of the fitted values, [C]Based on a test of skewness and kurtosis of residuals, [D]Based on the regression of squared residuals on squared fitted values. ARDL: Auto-regressive distributed lags

Table 5: Estimated long run coefficients using the ARDL approach ARDL (1,0,0,0,0) selected based on Schwarz Bayesian criterion

Dependent variable is *Log (Q)*		SE	Time period: 1974-2012
Regressor	Coefficient		*t*-ratio [*P*]
Log (PD)	−0.328	0.060	−5.438 [0.000]
Log (PE)	0.268	0.051	5.243 [0.000]
Log (Y)	0.747	0.285	2.623 [0.013]
Log (Mech)	0.012	0.151	0.082 [0.935]
C	5.671	0.484	11.707 [0.000]

ARDL: Auto-regressive distributed lags, PD: Price of diesel, PE: Price of electricity, SE: Standard error is appeared, i.e., mechanization would reduce the demand for manpower and livestock, and increase the demand for diesel and machinery. However, the intensity and significance of the effects differs between current study and the mentioned research. Indeed, this study failed to verify the meaningful effect of mechanization on demand for diesel.

The final step in ARDL analysis is to estimate the ECM, which has been reported in Table 6. It shows that the coefficient of the error correction term is about −0.49, so it is concluded that about 49% of the short-run disturbances in demand for diesel is adjusted towards the long-run equilibrium.

4. CONCLUSIONS

Although, agriculture sector is mainly dependent on geographical/natural conditions such as soil fertility and rainfalls, however it uses production factors including labor, capital, and energy, too. In particular, the large-scale planting and harvesting operations are accomplished by using heavy agricultural machineries, which use often diesel as fuel. Likewise, the water pumps utilize diesel for drawing water from wells. Furthermore, the farmers may carry farm products by diesel-driven motor vehicles.

The consumption of diesel increases with mechanization of agriculture, accessibility to diesel, relative low price, and rise in farmer incomes. Treating with diesel as production input requires considering the costs due to price changes in the supply side. The economic decisions in agriculture should be made according to the links between energy needs and agriculture production. These decisions concern with optimal allocation of resources available to farmers.

This paper analyzed empirically the per capita demand for diesel in Iranian agricultural sector using ARDL approach. The findings indicate that current diesel consumption follows its consumption over past periods, because agricultural firms cannot technically reduce diesel consumption in the short-run, or switch instantly among fuels. To some extent, this fact originates from major share of diesel use of agricultural machineries particularly in farming and gardening activities.

Another finding is a relatively inelastic demand for diesel in Iranian agriculture in both the short-run and long-run. Therefore,

Table 6: Error correction representation for the selected ARDL model ARDL (1,0,0,0,0) selected based on Schwarz Bayesian criterion

Dependent variable is *dLog (Q)*		SE	Time period: 1974-2012
Regressor	Coefficient		*t*-ratio [*P*]
dLog (PD)	−0.162	0.034	−4.877 [0.000]
dLog (PE)	0.132	0.038	3.429 [0.002]
dLog (Y)	0.369	0.133	2.765 [0.009]
dLog (Mech)	0.006	0.075	0.081 [0.936]
dC	2.778	0.543	5.122 [000]
ecm (−1)	−0.493	0.099	−4.969 [000]

PE: Price of electricity, PD: Price of diesel, ARDL: Auto-regressive distributed lags, SE: Standard error

the government policy on targeting energy subsidies is not able to reduce diesel use in large amounts. Hence, the non-price policies such as innovative managerial actions and usage of modernized machineries may result in lowering diesel consumption.

With regard to electricity tariffs, the estimation results show that diesel and electricity are weak substitutes for each other. It is worthwhile to note that substitutability occurs in particular subsectors of agriculture. For instance, water pumps can use diesel or electricity. In addition, there are some substitution capabilities for heating purposes in animal husbandry units.

The short-run and long-run income elasticities obtained for diesel indicate that diesel can be regarded as necessary input in agriculture. The low response of per capita diesel use to change in agricultural value-added per capita stems from the fact that agricultural activities are mainly dependent on the other main inputs including water, seed, fertilizers, manpower and land. Evidently, farming relies heavily on using soil and underground water or rainfall. As farmers seek usually to maximize their farm incomes, so the increases in total and per capita diesel use are usual, however diesel use can be reduced with using modern machines in agriculture. Hence, the interrelationship between higher incomes and utilization of modernized machineries should be considered. As a result, the net effect of high incomes and modernization of agricultural machineries on diesel use may be the subject for further researches in both national and international levels.

In analyzing the direct effect of mechanization on demand for diesel, no significant impact was found though the relevant cause and effect relationship had the expected sign. It is obvious that any addition to the stock of diesel-driven machineries naturally moves up diesel use. Of course, the composition of tractors in various powers can be modified to manage energy consumption efficiently in agricultural operations. According to the international standards, useful life of a tractor is 10 thousand hours. By this measure, more than 50% of existing tractors in Iran are classified as obsolete and out-of-dated. The old machines result in decreasing productivity and wasting fuels.

The long-run model in this paper gives long-run elasticities. As expected, all long-run elasticities are greater than short-run ones. The increasing incomes of farmers, diversifying the fuel mix in agriculture and modernizing machineries along with expanding promotion and counseling services may explain the increasing responsiveness of diesel demand to changes in the variables under consideration.

In comparison of short-run and ECMs, it can be concluded that all variables of the current study converge to each other over time, i.e. there is a long run and co-integrating relationship among them. In addition, the speed of adjustment in short-run distortions towards the long-run path is moderate.

Considering voluminous diesel consumption in the agricultural sector, any policy decision may affect the sector. Unification of diesel prices gives rise to increasing costs of production and prevents rents and corruption in this sector. Nevertheless, the debate to what extent diesel prices will increase ultimately depends on the government decisions on subsidies targeting plan.

Currently, diesel is supplied with both semi-subsidized rate of 5.6 cent[5] /L and non-subsidized rate of 13.2 cent/L to diesel-driven machinery, so the reductions in diesel consumption will be possible. In the long-run, diesel price unification may even reduce the smuggling of diesel at border regions. Farmers can replace old machinery with new equipment and add on saving diesel. In addition, they may employ more advanced farming techniques thereby optimize the use of farm machinery. The farmers should reduce diesel consumption and costs through electrification of diesel engines of wells and employment economical planting methods.

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5 1 US $= 26500 Iranian Rials (official exchange rate, mean of 9 months rate in 2014)