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RESEARCH PAPER

The Simulation of a Competitive Market for Gasoline in Iran: Using a Game Theory Approach

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Abstract
The economic growth and development of countries rely on energy; however, the limited and non-renewable nature of underground resources and petroleum products such as gasoline, along with the environmental pollution caused by their high consumption, calls for efficient utilization. Gasoline, of which Iran is the world's twelfth-largest consumer with a daily usage of 352,000 barrels, plays an important role in Iran's economy. However, the regulated price of gasoline, which does not reflect its true value and is not determined by a competitive market, hinders market efficiency. To address this, the present study estimated the relevant parameters by identifying the factors influencing supply and demand, using simultaneous equations for the period 2004–2018. Based on the results, the real price coefficient of gasoline is not statistically significant for demand, but the price coefficient of liquefied petroleum gas is significant, with the highest value at 0.2 in Kurdistan. The per capita income coefficient averages 0.7, being highest in Sistan and Baluchestan at 1 and lowest in Yazd at 0.3. For supply, the real price coefficient of gasoline indicates a decrease in supply despite a price increase, while technology has a positive effect. Through a cooperative game that models the players' objective functions, a Nash equilibrium was obtained for a simulated competitive market. Based on the competitive market prices, gasoline consumption was then determined. Given the potential for global supply and the significant difference between competitive and monopoly prices, liberalizing the gasoline market and supplying it globally are recommended, allowing market demand and supply to dictate its price. This approach would help control consumption, minimize welfare losses, and alleviate the government's budget pressures arising from subsidizing gasoline and distributing it unfairly among income deciles.
Keywords: competitive market, game theory, gasoline, simultaneous equations, supply and demand functions.
JEL Classification: D400, Q31.

Introduction

The level of production, services, economic growth, and development worldwide depends on energy consumption (Esfandiari, 2011; Gozgor et al., 2018). On the other hand, non-renewable underground resources have limited availability as an energy source and as an input to production; therefore, it is necessary to use them optimally (Nouri and Shiveh, 2006; Huang et al., 2020). Among these, transportation vehicles and machinery are some of the largest energy consumers, particularly of petroleum products such as gasoline, which are consumed daily in increasing quantities (Jahangard et al., 2006; Sharma and Shrestha, 2023). Currently, approximately 22.4 million barrels of gasoline and 26.2 million barrels of diesel are consumed daily worldwide, and Iran ranks twelfth among the highest-consuming countries, with a consumption of 352 thousand barrels of gasoline and 580 thousand barrels of diesel (United States Energy Information Administration, 2023). Additionally, according to Iran's Energy Balance Sheet, 99 percent of gasoline consumption is attributed to road transportation (Energy Balance Sheet, 2018).

Figure 1 depicts per capita gasoline consumption in Iran from 1969 to 2018 (MOP[1] statistics, 2018). According to Figure 1, the trend in per capita gasoline consumption has been upward from 1969 to 2018. For instance, from 1996 to 2005, gasoline consumption approximately doubled. The increase in gasoline consumption not only contributes to the depletion of non-renewable resources but also leads to higher greenhouse gas emissions, air pollution, and climate change. Moreover, despite the growth in per capita gasoline consumption, it is not feasible to increase domestic production in the short term due to the limited capacity of the country's refineries. Therefore, meeting the high demand necessitates government imports, which result in an outflow of foreign currency earnings from the country (Ghorbani and Mehregan, 2010). Consequently, optimal consumption is necessary, starting with an examination of the factors influencing gasoline demand, followed by the implementation of appropriate control policies.

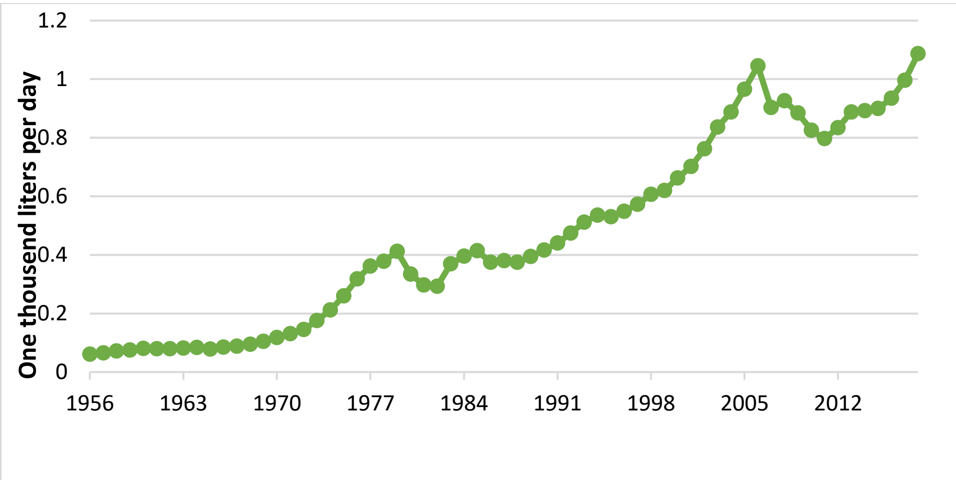

Figure 1. The Per Capita Gasoline Consumption Trend in Iran from 1969 to 2018
Source: The Ministry of Petroleum of the Islamic Republic of Iran.

The high consumption of gasoline in Iran is caused by non-price and price factors. Among the non-price factors, the higher average fuel consumption of

[1]. The Ministry of Petroleum of the Islamic Republic of Iran

domestic vehicles compared to foreign ones is due to inadequate technology or the obsolescence of these vehicles. Another contributing factor is the problems in public transportation, such as the lack of advanced monitoring technology for bus movements and station arrivals, as well as the shortage of public transportation vehicles. As for the price factors, an inappropriate pricing of gasoline can be mentioned. Firstly, it is determined administratively and is not the result of the supply and demand of the competitive market. Additionally, due to political and economic reasons, the import of this commodity is accompanied by high foreign-exchange costs. Another essential point is that the price of gasoline remains fixed for all income deciles in the country; therefore, low-income deciles receive less benefit from gasoline subsidies.

Considering the aforementioned factors, creating a competitive market can alleviate these problems. This is because optimal resource allocation becomes possible, and the real price is formed in such a market. With the presence of a real price, issues such as excessive gasoline consumption and subsequent environmental pollution, the existence of rent for smuggling, government costs for subsidies and their unfair distribution, and overall loss of welfare can be minimized.

A game-theoretic approach is utilized in this study for modeling a competitive market structure. By considering the characteristics of a market, various game approaches can be modeled to find market equilibrium and the intersection of functions. However, for modeling purposes, genetic algorithms, asymmetric function algorithms, simulated annealing algorithms, ant colony optimization, differential evolution, and other approaches have been introduced. Nonetheless, game theory has recently become one of the widely used and precise methods in pricing issues, improving the welfare of consumers and producers, and determining energy consumption in the market. Hadji et al. (2015), Yu et al. (2016), Zang et al. (2017), Peng and Tao (2018), and Tao and Gao (2020) all emphasize the application of game theory approaches in the mentioned cases.

Considering the importance of gasoline consumption in transportation, numerous studies have been conducted in this regard, some of which are mentioned. Emami et al. (2014) identified the influential factors affecting gasoline consumption and estimated the demand function for gasoline in Iran from 2002 to 2007 using panel data techniques. According to the results, per capita income, the number of vehicles, and diesel fuel prices have a direct relationship with consumption. Jahromi (2015) studied the use of artificial neural networks to examine the value-added tax for controlling gasoline consumption and showed that changes in gasoline prices due to the imposition of taxes do not have a significant impact on reducing consumption. Wadud (2015) estimated the supply and demand for gasoline in the aviation sector of the United States, considering factors such as price, income, population, and efficiency, and identified price increases as a tool to improve efficiency. Liddle et al. (2019) examined energy consumption in 26 countries and modeled demand as a function of national output (as income), energy prices, and dynamic lagged variables, concluding that income elasticity for energy demand is less than unity over time and price elasticity is negligible. Babaei et al. (2020) analyzed high gasoline consumption in Iran using game theory and evaluated the need for investment in refinery construction. In addition, Hashemi et al. (2020) estimated the gasoline demand function for different years in Iran using a state-space model. They also predicted various scenarios, suggesting that despite a 10% increase in gasoline price in the Sixth Development Plan, the gasoline demand would not decrease as expected. Therefore, to control gasoline consumption, they recommended that policymakers and planners determine an increase in gasoline prices exceeding 10% in the Sixth Development Plan, and this price increase should be progressive throughout the development program. Hunt and Kipouros (2023) compared gasoline demand in developing countries and estimated the influential factors as price, gross domestic product, land area, temperature, cooling and heating degree-days, and stock market value, with results suggesting that technical efficiency is the main driver of consumption. Based on a review of the conducted studies, most researchers have estimated the supply and demand functions for gasoline using different methods by analyzing the factors influencing them. However, the aim of the current research is not only to identify the factors affecting the supply and demand functions for gasoline in Iran and estimate them for the period of 2004 to 2018, but also to estimate the equilibrium price and quantity resulting from a competitive market using a game-theoretic approach.

Materials and Methods

Since the market consists of two main elements, supply and demand, the interaction of supply and demand determines the equilibrium price and quantity in the market. Theoretically, factors affecting demand include the price of the commodity itself, other goods, and consumer income, while supply is a function of the price of the product, the prices of inputs, and technology. However, in addition to these factors, empirical variables may also influence supply and demand functions depending on the type of product and the specific time and location. These functions are shown in Equations (1) and (2).

$$D_1 = f(p_1, p_2, m) \tag{1}$$

$$S_1 = f(p_1, p_2, t) \tag{2}$$

where D_1 represents the quantity demanded, S_1 shows the quantity supplied, p_1 and p_2 are “the price of the commodity” and “the price of other goods or inputs”, and m and t denote “consumer income” and “technology”. For a normal good, the quantity demanded has an inverse relationship with its price and a direct relationship with income. Additionally, the demand for any good has a direct relationship with the price of its substitute and an inverse relationship with the price of its complement. The supply of a product also has a positive relationship with technology and the price of the product, and an inverse relationship with the price of inputs (Varian, 2014).

Equations (1) and (2) represent the implicit forms of the demand and supply functions, which need to be explicitly written in order to estimate them. For this purpose, and based on the literature, four functional forms, namely linear-linear, logarithmic-linear, linear-logarithmic, and logarithmic-logarithmic, have been used for simultaneous models, as demonstrated in Equations (3) to (6), with the variables selected in accordance with previous studies.

Case 1: Lin-Lin Demand-Supply System

$$\begin{aligned} &Cp{+}\beta_0 + \beta_1 Pp + \beta_2 Pg + \beta_3 GDP \\ &\mathrm{Sp} = a_0{+}a_1\mathrm{Pp}{+}a_2 t \end{aligned} \tag{3}$$

Case 2: Log-Lin Demand-Supply System

$$\begin{aligned} &\mathrm{Log(Cp)} = \beta_0 + \beta_1 Pp + \beta_2 Pg + \beta_3 GDP \\ &\mathrm{Log(Sp)} = a_0 + a_1 Pp + a_2 t \end{aligned} \tag{4}$$

Case 3: Lin-Log Demand-Supply System

$$\begin{aligned} &\mathrm{Cp} = \beta_0 + \beta_1 \log(Pp) + \beta_2 \log(Pg) + \beta_3 \log(GDP) \\ &\mathrm{Sp} = a_0 + a_1 \log(Pp) + a_2 \log(t) \end{aligned} \tag{5}$$

Case 4: Log-Log Demand-Supply System

$$\begin{aligned} &\mathrm{Log(Cp)} = \beta_0 + \beta_1 \log(Pp) + \beta_2 \log(Pg) + \beta_3 \log(GDP) \\ &\mathrm{Log(Sp)} = a_0 + a_1 \log(Pp) + a_2 \log(t) \end{aligned} \tag{6}$$

In Equations (3) to (6), C_p is per capita gasoline demand in the province, S_p is per capita gasoline supply in the province, P_p and P_g are the respective deflated prices of gasoline and liquefied gas, and GDP is the real per capita gross domestic product of each province.

To select the optimal form among Equations (3) to (6), the Box-Cox test can be used (Hosseinzad et al., 2023). The consistency of signs, parameter values of the function, and economic theories' predictions are among the criteria for choosing the best model over other measures (Hosseinzad and Salami, 2005). As mentioned, the equilibrium price and quantity are determined by the equality of supply and demand. However, market structures will vary depending on how prices are formed. Given the regulated pricing of gasoline and the absence of a competitive market for this good, it is necessary to simulate a competitive market in addition to the existing market. In the present study, a cooperative game will model the competitive market because a two-way interaction between market players, namely consumers and gasoline suppliers, is possible. Therefore, it is necessary to first determine the objective functions of the market players. The profit function of energy suppliers, as the objective function of this group, will be formulated as Equation (7) (Su and Huang, 2014; Azad and Ghotbi, 2017).

$$\begin{aligned} &\mathrm{Max}_{\prod_{it}} = (R_{it} - C_{it}) \\ &\text{s.t.} \quad 0 < \mathrm{pr} < pr_{max} \end{aligned} \tag{7}$$

In Equation (7), R_{it} represents revenue, C_{it} represents production cost, and pr_{max} corresponds to the maximum production level.

The objective function of gasoline consumers is also represented in Equation (8) (Su and Huang, 2014; Azad and Ghotbi, 2017).

$$C_d = (P_{it} * D_{it}) \tag{8}$$

where C_d represents consumer cost, D_{it} represents total demand, and P_{it} represents the price of the desired commodity. To achieve equilibrium price and optimal consumption, it is necessary to formulate the mathematical model of a competitive market considering the objectives of the players. The intersection points between the objective functions of the players in Equations (7) and (8) will determine the equilibrium price and quantity. Therefore, the cooperative game under competitive market conditions is formulated as Equation (9) (Su and Huang, 2014; Azad and Ghotbi, 2017).

$$\begin{aligned} &= \mathrm{C_d} \prod_{it} \\ &(R_{it} - C_{it}) = (P_{it} * D_{it}) \\ &\text{s.t.} \quad 0 < \mathrm{pr} < pr_{max} \end{aligned} \tag{9}$$

In this case, the equilibrium price and consumption are determined by the intersection of market forces according to the Nash equilibrium. After estimating the coefficients of the functions using the simultaneous equations method, the equilibrium values are obtained by optimizing the supply and demand functions (Su and Huang, 2014; Azad and Ghotbi, 2017).

It should be noted that due to the diversity of conditions in different provinces of Iran, such as population, transportation infrastructure, and economic and geographical conditions, it is necessary to separately simulate a competitive market for each province. Also, because of the fluctuating prices of gasoline in some years, in the present study, weighted average prices were calculated, taking into account the share of gasoline consumption at each price. Furthermore, due to high inflation, nominal prices are not a good indicator of consumer behavior. Therefore, they have been adjusted using the Consumer Price Index in 2016.

The required statistics and information for the present study were collected from 28 provinces during the period of 2004 to 2018. In this regard, the price statistics of petroleum products and provincial gasoline demand were obtained from the statistics of MOP, and the gross domestic product and provincial population information were obtained from the portal of the Statistical Center of Iran.

The mean, standard deviation, and coefficient of variation for some important variables such as per capita gasoline consumption and per capita provincial income are reported in Table 1. According to Table 1, the average per capita gasoline consumption from 2004 to 2018 was equivalent to 325 thousand liters, with the highest consumption of 556.8 thousand liters belonging to Hormozgan province in 2018 and the lowest consumption of 196 thousand liters belonging to Lorestan province in 2011. In addition, the average real income per person for the provinces was 1.8 million Rials, with the minimum and maximum values belonging to Sistan and Baluchestan and Bushehr provinces with 0.47 million and 9.1 million Rials in 2004 and 2014, respectively.

Table 1. Descriptive Statistics

Variable	Observations	Mean	Standard Deviation	Coefficient of Variation	Minimum (Province-Year)	Maximum (Province-Year)
Per capita gasoline consumption (thousand liters)	420	325.0438	74.51824	0.229256	196.096 (Lorestan-2011)	556.818 (Hormozgan-2018)
Real per capita income (million Rials)	420	1.86126	1.453293	0.7808114	0.47 (Sistan and Baluchestan-2004)	9.198 (Bushehr-2014)

Source: Research finding.

Table 2. The Result of Estimating the Simultaneous Equations of Gasoline Supply and Demand

Province	a_0	a_1	a_2	β_0	β_1	β_2	β_3
East Azarbaijan	-146.6	-0.34***	21.2***	5.35***	0.06	-0.07	0.42
West Azarbaijan	-125.9	-0.49***	18.4	5.9***	-0.01	-0.1	0.21
Ardabil	-144.4	-0.37***	20.9	5.4***	0.08	-0.11***	0.35
Esfahan	-139.02***	-0.23***	20.1***	3.9***	0.5	-0.16	0.52
Ilam	-320.6***	-0.32***	45.2***	2.5	0.83	-0.22	0.12
Bushehr	-296.2***	-0.22	41.9***	-0.54	1.9	-0.4	-0.28
Tehran	-40.5	-0.06	6.4	4.8***	0.33	-0.1	0.03
ChaharMahal Bakhtiari	-228.1***	-0.29***	32.4***	3.7***	0.54	-0.18	0.43
Khorasan	-171.8***	-0.22***	24.6***	4.1***	0.4	-0.14	0.53
Khuzestan	-242.9***	-0.37***	34.5***	3.05	0.68	-0.21	0.15
Zanjan	-321.7***	-0.38***	45.4***	5.1***	0.14	-0.09	0.72***
Semnan	-111.1	-0.25***	16.3	4.9***	0.33	-0.13	0.08
Sistan and Baluchestan	-369.4***	-0.43***	52.1***	7.2***	-0.19	-0.09	1.01***
Fars	-230.2	-0.33	32.8	3.1	0.79	-0.22	-0.09

Qazvin	-176.5	-0.32***	25.4	4.3***	0.44	-0.16	0.06
Ghom	-216.3***	-0.31***	30.8***	3.9***	0.54	-0.18	0.53
Kurdestan	-252.9***	-0.39***	35.9***	3.9***	0.5	-0.19***	0.5
Kerman	-282.02***	-0.3***	39.9***	4.2***	0.42	-0.14***	0.65***
Kermanshah	-80.3	-0.4***	12.1	5.8***	-0.02	-0.08	0.09
Kohgluye and Boyerahmad	-258.5***	-0.25***	36.6***	0.63	1.5	-0.49	-0.3
Golestan	-103.2	-0.41***	15.2	6.2***	-0.16	-0.02	0.55
Gilan	-229.7***	-0.27***	32.7***	4.8***	0.3	-0.11	0.42
Lorestan	-322.1***	-0.38***	45.4***	4.6***	0.27	-0.14***	0.96***
Mazandaran	-199.4***	-0.19	28.5***	4.04***	0.51	-0.16***	0.59
Markazi	-244.7***	-0.43***	34.8***	4.6***	0.25	-0.13***	0.61**
Hormozgan	-355.2***	-0.12	49.9***	0.77	1.35	-0.32	0.5
Hamadan	-273.2***	-0.31***	38.7***	3.9***	0.45	-0.15***	0.7***
Yazd	-250.9***	-0.22***	35.6***	4.6***	0.36	-0.14***	0.35***

Source: Research finding.

Note: The symbol "***" represents a significant level of 1%.

Table 3. Result of Gasoline Price Estimation in a Competitive Market (in Rials per liter)

Province	East Azarbaijan		West Azarbaijan		Ardabil		Esfahan		Ilam		Bushehr		Tehran	
Year	**T**[1]	**P**[2]	**T**	**P**	**T**	**P**	**T**	**P**	**T**	**P**	**T**	**P**	**T**	**P**
2004	571.0	252.9	650.3	267.6	564.0	244.7	788.0	360.4	520.7	242.7	768.0	349.3	845.8	391.8
2005	528.9	265.6	587.9	284.9	521.7	257.7	732.5	374.3	495.0	258.8	729.4	368.2	773.9	396.3
2006	673.1	280.2	763.6	305.3	657.2	272.7	883.0	390.1	743.2	277.2	897.9	389.2	902.6	401.2
2007	591.4	283.4	653.3	307.5	582.7	275.6	808.6	394.7	578.6	285.2	793.2	400.1	800.0	402.7
2008	493.7	297.6	524.4	327.3	492.2	290.2	678.9	410.0	490.8	304.2	660.2	421.6	685.4	407.3

[1]. Total Cost of Monopoly

[2]. Price Derived from Competitive Market

2009	326.8	299.9	330.3	328.1	322.1	292.2	449.8	413.8	336.6	312.0	458.9	432.4	456.0	408.6
2010	352.8	265.5	515.5	272.1	504.6	255.6	681.1	381.6	487.8	283.4	640.9	407.0	728.3	399.4
2011	376.4	220.7	718.3	206.0	685.9	209.0	892.2	336.9	644.7	242.7	823.0	367.6	919.1	385.6
2012	355.3	242.1	678.6	233.6	626.5	230.7	787.8	360.7	596.7	269.6	733.7	398.6	790.8	393.4
2013	332.7	269.6	545.5	270.8	514.5	258.8	699.6	390.2	523.5	303.7	642.4	436.6	680.5	402.6
2014	365.2	246.4	626.1	235.4	617.5	234.4	811.0	367.9	611.5	284.3	731.4	419.8	805.3	396.0
2015	672.2	241.4	409.5	226.4	416.4	228.9	548.3	364.1	427.1	284.0	522.4	422.5	547.2	395.0
2016	436.1	247.7	341.3	233.0	348.8	235.0	475.4	372.2	384.5	296.3	472.1	438.4	490.9	397.7
2017	211.4	259.5	383.7	247.2	401.9	246.8	550.1	385.9	455.2	315.2	547.3	461.2	565.4	402.1
2018	237.8	284.3	377.6	279.8	388.9	272.1	545.1	412.8	440.4	349.6	567.4	499.8	560.6	410.1
Province	**ChaharMahal Bakhtiari**		**Khorasan**		**Khuzestan**		**Zanjan**		**Semnan**		**Sistan and Baluchestan**		**Fars**	
Year	**T**	**P**	**T**	**P**	**T**	**P**	**T**	**P**	**T**	**P**	**T**	**P**	**T**	**P**
2004	567.2	241.2	561.8	255.2	615.7	261.1	568.8	251.5	990.8	421.4	642.4	269.0	735.5	323.6
2005	525.3	254.4	525.6	265.6	568.0	277.9	540.0	269.9	896.2	437.5	587.2	291.4	683.1	342.5
2006	639.9	269.3	652.0	277.3	704.4	297.3	685.2	291.3	1032.9	455.8	810.3	317.6	826.6	364.1
2007	577.7	274.7	583.2	281.5	621.7	303.3	615.0	299.6	894.4	459.7	628.5	328.0	750.6	371.3
2008	475.5	289.6	496.2	293.0	507.4	322.8	525.5	321.6	768.4	477.3	593.7	355.3	622.0	392.9
2009	326.0	294.5	334.8	296.8	344.3	328.2	356.3	329.5	499.5	480.2	358.9	365.4	420.6	399.4
2010	486.4	267.3	823.0	275.9	541.4	289.0	505.9	291.5	807.2	437.6	511.3	319.1	650.5	357.5
2011	671.3	229.7	655.9	246.2	710.9	237.4	685.2	240.2	1075.6	380.3	726.6	257.5	843.8	301.0
2012	596.9	251.6	589.0	263.7	641.1	265.1	631.5	270.9	905.8	408.1	727.2	294.7	746.3	332.4
2013	518.7	279.1	492.8	285.2	540.2	301.0	536.3	310.6	765.4	443.0	561.5	343.6	648.8	372.4
2014	587.2	260.6	592.9	270.9	612.5	274.7	641.1	285.0	892.3	413.7	693.1	312.5	747.0	344.0
2015	413.6	258.5	413.3	269.3	427.5	270.6	445.8	282.7	586.7	407.4	430.3	310.1	515.2	340.1
2016	360.0	267.1	361.6	276.0	378.9	280.7	383.9	295.6	505.9	415.5	393.4	326.2	445.2	351.9
2017	414.4	281.0	424.3	286.8	441.7	297.9	443.2	316.4	588.0	430.6	504.9	352.3	518.5	371.4
2018	400.4	307.4	415.0	306.9	417.2	297.9	446.9	356.2	583.6	461.6	471.9	402.4	508.2	409.6
Province	**Qazvin**		**Ghom**		**Kurdestan**		**Kerman**		**Kermanshah**		**Kohgluye and Boyerahmad**		**Golestan**	
Year	**T**	**P**	**T**	**P**	**T**	**P**	**T**	**P**	**T**	**P**	**T**	**P**	**T**	**P**
2004	802.3	344.4	762.3	333.7	552.8	234.6	721.1	311.6	621.4	263.7	503.4	231.8	572.3	240.2
2005	731.3	362.3	704.1	352.0	513.9	250.3	666.3	330.4	563.8	276.8	480.5	244.2	522.3	253.0
2006	897.1	382.9	854.6	372.8	637.4	268.6	826.5	351.8	722.9	292.1	606.9	258.1	643.7	268.0
2007	757.4	388.4	761.7	379.7	576.9	274.3	733.8	360.7	619.3	293.2	552.4	264.2	559.4	269.6

2008	656.1	408.5	644.7	400.5	506.3	292.7	592.1	382.4	490.7	307.7	480.6	278.3	454.6	283.9
2009	426.5	413.1	422.0	406.7	320.8	297.8	404.6	391.0	321.0	307.6	330.8	284.1	300.3	284.5
2010	124.8	368.7	645.6	366.6	469.1	260.6	591.2	356.6	544.0	264.1	460.1	262.9	485.6	243.4
2011	904.9	309.9	836.4	312.1	663.5	212.2	784.9	307.8	724.5	210.7	617.5	231.9	638.4	193.0
2012	809.5	339.9	740.0	342.5	599.5	238.1	714.6	339.0	675.9	232.7	568.6	252.5	571.3	214.3
2013	656.8	378.2	647.9	381.1	510.3	271.9	622.1	378.4	544.9	261.6	496.1	278.0	463.4	242.4
2014	789.5	348.2	743.7	353.8	629.7	247.0	689.6	355.0	615.9	233.2	582.7	263.5	540.2	215.6
2015	522.4	342.6	499.6	350.1	413.0	243.2	484.5	354.0	417.5	225.5	412.6	263.3	372.9	208.7
2016	453.4	352.5	429.5	361.4	348.6	252.6	438.9	367.7	358.1	230.4	361.6	272.5	323.5	213.8
2017	522.5	369.9	497.2	380.3	383.7	268.8	523.9	389.0	416.5	241.1	417.7	286.5	377.9	224.5
2018	518.6	405.2	499.7	416.9	378.0	301.2	517.7	427.9	393.9	265.9	400.3	311.5	360.7	249.0
Province	**Gilan**		**Lorestan**		**Mazandaran**		**Markazi**		**Hormozgan**		**Hamadan**		**Yazd**	
Year	**T**	**P**	**T**	**P**	**T**	**P**	**T**	**P**	**T**	**P**	**T**	**P**	**T**	**P**
2004	793.4	338.7	456.7	190.6	866.2	388.5	714.1	304.2	688.8	319.0	508.0	221.4	753.7	373.1
2005	727.0	356.4	426.3	204.5	801.1	404.2	659.9	325.6	658.2	335.0	479.3	234.8	729.6	391.5
2006	886.7	376.6	539.7	220.6	981.0	421.7	814.9	350.7	818.1	352.3	593.9	250.2	906.3	412.2
2007	752.1	384.2	479.4	226.9	862.1	429.5	716.4	357.7	709.2	364.6	537.2	256.2	869.3	421.7
2008	639.9	404.4	404.9	243.5	724.2	446.8	606.2	382.9	597.0	382.8	451.9	271.8	737.7	442.5
2009	427.8	411.5	274.4	249.5	484.0	454.2	399.9	388.9	437.8	395.7	311.8	277.5	505.8	451.8
2010	704.6	376.6	404.9	221.0	761.4	428.8	626.5	334.7	593.2	389.8	459.4	251.5	667.5	422.8
2011	920.8	327.5	565.4	182.6	988.1	390.7	828.9	266.0	766.8	375.0	626.3	215.2	876.1	379.6
2012	819.5	357.1	520.3	205.7	883.6	416.7	745.5	301.0	694.5	400.1	565.4	237.6	837.6	410.1
2013	671.4	394.2	444.1	235.6	744.4	448.2	620.4	347.1	580.2	429.2	494.6	265.9	796.2	447.4
2014	786.1	370.4	514.1	216.4	869.7	430.9	735.5	311.3	680.3	427.8	569.5	248.2	896.9	427.9
2015	534.1	368.3	361.6	214.8	589.1	431.0	495.5	304.9	507.7	437.6	406.5	246.9	617.6	428.6
2016	472.9	380.3	320.3	224.6	522.6	442.6	423.9	316.9	471.7	455.3	352.1	256.3	529.0	442.8
2017	563.6	399.4	382.0	240.3	599.0	459.8	502.3	338.2	574.4	477.5	423.8	271.2	607.4	463.9
2018	562.5	435.1	366.5	270.3	598.5	490.0	488.8	382.0	577.0	509.1	417.5	299.1	609.8	500.7

Source: Research finding.

Result and Discussion

Considering the mentioned criteria for selecting an appropriate functional form, the logarithmic system in Equation (6) is chosen as the preferred model. To estimate the coefficients in Equation (6) using a system of simultaneous equations, rank and order conditions were initially examined. Since the equations of demand and supply in the mentioned system are exactly identified and over-identified, a two-stage least squares method was employed (Gujarati, 2009; Akbarian and Famkar, 2011; Maleki et al., 2017). Then, the coefficients of the supply and demand equations in each of the 28 provinces were estimated using STATA-17 software, and the results are reported in Table 2. It should be noted that the coefficients of the supply and demand system, selected due to the logarithmic form, have an elasticity interpretation.

According to the estimation results of simultaneous equations of supply and demand in Table 2, the coefficients of real gasoline prices as a function of demand in the studied provinces are not statistically significant. This implies that gasoline consumption is not affected by the determined price. Additionally, the coefficient of liquefied petroleum gas prices is significant in certain provinces, with the highest value belonging to Kurdistan province, indicating that with a 1% increase in real gas prices, per capita gasoline consumption in this province only decreased by 0.2%. On the other hand, the significance of the negative coefficient of gasoline prices as a function of supply in most provinces indicates that despite the increase in real gasoline prices, gasoline supply has decreased. The significance of income elasticity in some provinces and its positive sign indicate that if the real income of the province increases by 1% per capita, gasoline consumption on average increases by 0.7%, with the highest and lowest effects belonging to Sistan and Baluchestan and Yazd provinces respectively, with values of 1% and 0.3%. It should be noted that none of the coefficients are significant in Fars province. In all provinces, the significance of the technology coefficient and its positive sign indicate the existence of a positive relationship between technology and gasoline supply. Furthermore, the significance of the intercept in the supply and demand equations indicates that besides the considered variables, other factors have also influenced supply and demand.

Based on the estimated coefficients of the model, the real price associated with the competitive market for gasoline in selected years has been estimated for 28 provinces and reported in Table 3. The monopolist's total cost is derived from the sum of the existing regulated price and per capita provincial subsidies[1].

According to Table 3, the total cost of the monopolist in all provinces, except for the years 2017 and 2018 in East Azerbaijan province, is approximately twice the competitive prices. The highest and lowest competitive prices are 435.3 and

[1]. The calculations related to estimating competitive prices were performed using MATLAB-R2022 software.

223.1 Rials, respectively, for Semnan and Lorestan provinces. Additionally, the corresponding monopolistic prices are 786.2 and 435 Rials for Semnan and East Azerbaijan provinces, respectively. It should be noted that in 2009, there was a slight difference between competitive and monopolistic prices for all provinces. For better visualization, the average competitive price and total cost of the monopolist for 28 provinces from 2004 to 2018 have been calculated and reported in Figure 2. By analyzing Figure 2, it can be concluded that on average, in Iran, the monopolistic cost exceeds the estimated price of gasoline for a competitive situation. Despite the regulated prices, the government compensates for the monopolistic cost by providing subsidies.

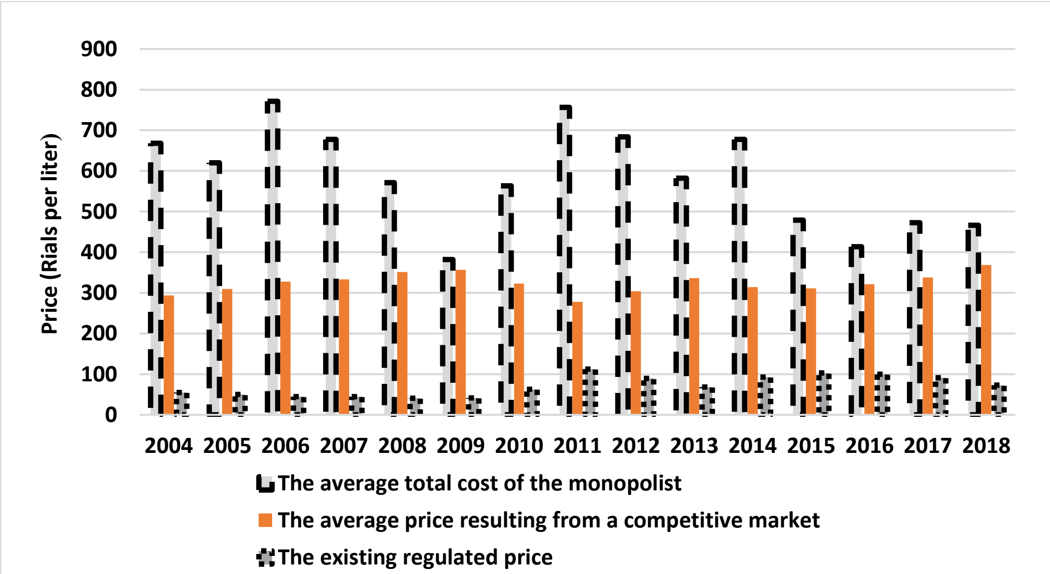

Figure 2. Comparing Competitive Pricing and Monopolistic Cost with the Regulated Price of Gasoline Nationwide
Source: Research finding.

Furthermore, by considering average prices and their placement in the demand function, the trend of average per capita gasoline consumption in Iran is depicted in Figure 3. According to Figure 3, the average per capita gasoline consumption in provinces has decreased in competitive conditions compared to the current situation.

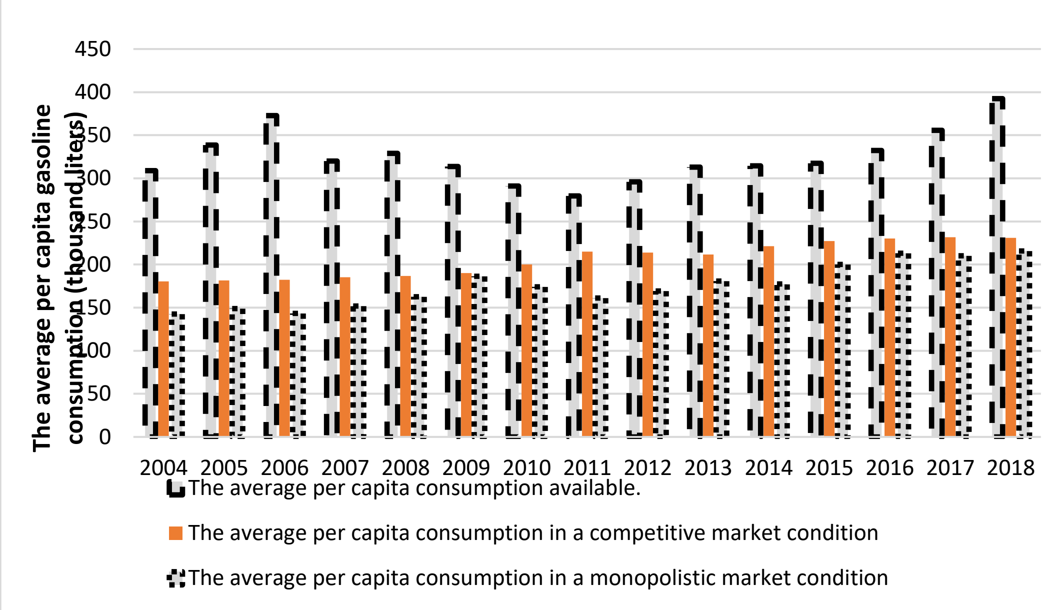

Figure 3. Comparing the Average Per Capita Gasoline Consumption in Monopoly and Competitive Conditions with the Current Situation in the Country
Source: Research finding.

Conclusion

Since the gasoline price in Iran is set by government regulations rather than market forces, it leads to several issues such as rising gasoline consumption, environmental pollution, smuggling to other countries, and ultimately, a reduction in market efficiency. According to research findings, and the identification of factors influencing gasoline consumption, the real price coefficient of gasoline for the studied provinces does not have statistical significance, indicating that gasoline consumption in Iran is not influenced by its price, which could be attributed to the regulated pricing. Although the nominal price increases every few years, considering inflation and the higher increase in the real prices of other goods, gasoline becomes cheaper. According to demand theory, this leads to an increase in its consumption.

Another crucial point is that prices are determined by the interplay of market supply and demand, but their formation differs based on the market structure. In Iran, the gasoline market operates under a monopolistic structure, which is inherently less efficient than a competitive market. Based on the estimated prices resulting from the game theory approach in this study, the monopolistic cost is higher than the price in a competitive market. On the other hand, the difference between the high cost of monopoly and the current regulated price in the market is compensated by government subsidies, which puts significant pressure on the government budget and can lead to budget deficits and inflation. Additionally, despite the regulated price for gasoline in Iran and the increasing demand for it, the government is forced to import gasoline to meet consumption needs, which also leads to an increase in government expenses. Therefore, it is recommended to create competition in the market and achieve efficiency by restructuring the market for this commodity through privatization and liberalization policies, such as granting citizens' rights to gasoline (or gasoline vouchers/entitlements) and allowing Iranian individuals to buy and sell these rights, as well as its global supply due to the high international price of this commodity.

The aim of such policies is to bring the market as close as possible to competitive market conditions and avoid setting it by regulation. This, along with the correct reflection of the value of gasoline, intelligently reduces gasoline consumption and environmental pollution, and also alleviates the budget pressure on the government to pay gasoline subsidies. According to the statistics of MOP, approximately 45.3 trillion Tomans of the government's budget was spent on gasoline subsidies in 2018. It seems that global gasoline supply and its price liberalization will maximize the welfare of the entire society.

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